

THE POWER OF SCIENCE:
ORIGINS OF AMERICAN SCHOLARLY COMMUNICATION, 1840 – 1900

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This dissertation proposes to answer several questions that arise from the actions of American scientists between 1840 and 1900. How did the broader organization of science in the late nineteenth century create a system of professional disciplines? Why did the American Association for the Advancement of Science (AAAS) form, and why did specialized societies like the American Chemical Society (ACS) later found an organization separate from the AAAS? Why did these professional societies create journals, and how did these journals help to communicate science? Often, scholars of scholarly communication will either use quantitative methods such as bibliometrics and scientometrics on individual academic journals, or, they will employ historical and sociological methods to answer broader questions about social trends in American science. This dissertation will combine these methods within the context of nineteenth-century American science and will utilize both quantitative textual analysis methods and qualitative historical and sociological analysis. It is hoped that by broadening the methods used, and by better understanding the early deliberations of scientists before there was a formal scholarly communication system, it may be possible to contextualize current debates about the need for changes in scholarly communication.

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Table of Contents

Acceptance.....	ii
Acknowledgements.....	iii
Abstract.....	iv
Introduction	1
<i>Theories of Scholarly Communication</i>	4
Sociology of Science and Scientometrics.....	4
Sociology of Professions	5
<i>Combining Methods</i>	6
Literature Review	10
<i>The Institutionalization of Science</i>	10
<i>Professional Societies and Universities</i>	13
Theories of Professionalization.....	14
Histories of Professionalization	25
History of Universities.....	36
<i>History of Scientific Journals</i>	46
Early History of Journals: Seventeenth and Eighteenth Centuries	48
Later History of Journals: The Nineteenth Century	58
<i>The Intersections of Institutionalization, Professionalization, and Journals</i>	66
Pre-History of American Scholarly Communication	68
<i>Early Science in England</i>	69
<i>American Science Before Centralization</i>	74
<i>Struggles for Power: The American Association for the Advancement of Science (AAAS) and Challenges to National Organization</i>	78
<i>Brief History of the American Association for the Advancement of Science and the American Chemical Society</i>	82

Alexander Dallas Bache and His Circle	84
<i>University Reform</i>	86
<i>Geology and Industry</i>	91
<i>Division of Knowledge</i>	94
<i>Creating an Aristocracy of Science</i>	96
 American Chemical Society (ACS)	102
<i>Aristocrats and Industry</i>	103
<i>A Union of Societies</i>	109
<i>Subdivision</i>	112
<i>Sharing Information</i>	115
 Scientific Journals, 1818 – 1922	118
<i>A Brief History of Nineteenth-Century American Scientific Publishing</i>	120
<i>Methodology for Analysis of Journals</i>	122
<i>American Journal of Science (AJS), 1818 – 1922</i>	131
<i>Proceedings of the American Association for the Advancement of Science (PAAAS), 1848 – 1915</i>	136
<i>Journal of the American Chemical Society (JACS), 1876 – 1922</i>	140
<i>Topic Model of the Full Corpus (AJS, PAAAS, and JACS), 1818 – 1922</i>	144
 A Counterexample: The Career of T.A. Wylie	148
<i>The Purpose of Science and Education</i>	149
<i>The Purpose of Scholarly Publishing</i>	151
 Conclusion.....	154
 Bibliography	159
<i>Primary Sources</i>	159
<i>Secondary Sources</i>	162

Appendix I Visualization of the percentage of all categories in the <i>American Journal of Science</i> 1819 – 1922	171
Appendix II Percentage of Topics in the <i>American Journal of Science</i> All years 1819 – 1922	172
Appendix III Trends in number of topics in the <i>American Journal of Science</i> 1819 – 1922	173
Appendix IV Topics represented as a percentage of the whole in the <i>American Journal of Science</i> 1819 – 1922	174
Appendix V Percentage of Topics in the <i>Proceedings of the American Association for the Advancement of Science</i> All years 1848 – 1914	175
Appendix VI Percentage of all categories in the <i>Proceedings of the American Association for the Advancement of Science</i> 1848 – 1914.....	176
Appendix VII Topics represented as a percentage of the whole in the <i>Proceedings of the American Association for the Advancement of Science</i> 1848 – 1914	177
Appendix VIII Distribution of Expected and Unexpected Topics grouped by editorial years - <i>Journal of the American Chemical Society</i> 1819 – 1922	178
Appendix IX Topic Model of All Journals Utilizing Documents of 1,000 Words.....	179
Appendix X Visualization of Categories for Topic Model of All Journals Utilizing Documents of 1,000 Words, 1818 - 1922.....	199
Appendix XI Word List and Rates per 1000 for Business and Method Related Words in the <i>Journal of the American Chemical Society</i>	200

Curriculum Vitae

Introduction

Alexander Dallas Bache (1806-1867), scientist, government administrator, and university professor addressed the American Association for the Advancement of Science (AAAS), the first national scientific society in the U.S., and asserted that, “While Science is without organization, it is without power: powerless against its enemies, open or secret; powerless in the hands of false or injudicious friends.”¹ When Bache was writing in the 1850s there were many decentralized educational institutions such as public schools, lyceums, and some religiously-affiliated universities. There was only one consistently published scientific journal, the *American Journal of Science*, one scientific professional association, the AAAS that Bache helped to found, and only the beginnings of government-sponsored scientific institutions including the Smithsonian and the National Academy of Sciences. Fifty years after Bache gave this speech, state-sponsored universities existed through the Morrill Act along with a nation-wide public-school system. There were multiple scientific journals, many of them published by specialized scientific societies that formed out of the AAAS, and the government was taking a greater interest in scientific work. In all, the kind of power to which Bache referred seems to have been established in the U.S. during a roughly sixty-year period (1840 – 1900). Moreover, the power structure created during this period became embedded in other scientific systems like academic publishing that are now an important part of scientific work both in the U.S. and around the world.

¹ Spencer F. Baird, ed. *Proceedings of the American Association for the Advancement of Science*. New York: G. P. Putnam, 1852, lii - liii.

How did this establishment of scientific power desired by Bache happen? This dissertation hopes to answer that and several related questions that arise from the actions of Bache and other scientists between 1840 and 1900. How did the broader organization of science in the late nineteenth century create a system of professional disciplines? Why did the AAAS form, and why did specialized societies like the American Chemical Society (ACS) later form independently from the AAAS? Why did these professional societies create journals, and how do these journals help to communicate science? Finally, how did the system of scientific societies develop alongside the system of departments within universities? Universities, scholarly journals, and professional societies are all a part of a complex scholarly communication system, and by understanding the history of the intersections between these components, it may be possible to better understand why Bache and others created the scientific environment in the way that they did. More importantly, understanding the early debates of these scientists may help to contextualize current debates about the need for changes in scholarly communication such as addressing inequalities for women, persons of color and other underrepresented groups within the academic publishing system. This dissertation will also contribute to an ongoing discussion in professional circles about the future of scholarly communication.

Scholarly communication has been debated over many years, and recently Aileen Fyfe and other historians of science have worked to provide some historical context on the history of academic publishing, principally in the context of the Royal Society of London.² Fyfe's research, however, falls within a well-established framework of investigation for scholarly communication. Christine Borgman defines scholarly communication as, "the study of how

² Aileen Fyfe,, Kelly Coate, Stephen Curry, Stuart Lawson, Noah Moxham, and Camilla Mørk Røstvik. 2017. *Untangling Academic Publishing: A History of the Relationship Between Commercial Interests, Academic Prestige, and the Circulation of Research*. <https://doi.org/10.5281/zenodo.546100>.

scholars in any field (e.g. physical, biological, social, and behavioural sciences, humanities, technology) use and disseminate information through formal and informal channels.”³ Much of the literature, like Fyfe’s, utilizing Borgman’s definition has focused on the idea of prestige, and much of the current research on scholarly communication relies on the work of Robert Merton for a framework. Merton concentrated on the values of the modern scientific system and the ways in which individual scientists achieved status within their professions.⁴ Eugene Garfield, founder of the Institute for Scientific Information citation index is but one example of the many sociologically trained scientists who have investigated scholarly communication according to Merton’s methods. Garfield used the citation index to measure the prestige and status of scientists by analyzing the number of citations scholars received for their publications. Overall, Garfield believed that, “Those of us who have worked in the field of scientometrics and its antecedent bibliometrics almost universally recognize the debt we owe to Robert K. Merton.”⁵

Other scholars, however, have questioned Merton’s framework of utilizing prestige as the most important factor in understanding scholarly communication. For example, Scott Frickel and Neil Gross, when discussing the approach of Merton and others to measure status suggest that, “we find it difficult to believe that the quest for prestige and status is the sole motive shaping intellectual innovation.”⁶ Therefore, it is important to ask what might be another possible framework for investigating scholarly communication? Perhaps by taking into account some of Frickel and Gross’s theories about power in scientific movements and combining those

³ Christine Borgman, ed. *Scholarly Communication and Bibliometrics*. (Newbury Park, CA: Sage, 1990), 13-14.

⁴ Robert Merton, *Social Theory and Social Structure*. (New York: Free Press, 1968).

⁵ Robert K. Merton, *Social Theory and Social Structure* and Eugene Garfield, “The Intended Consequences of Robert K. Merton.” *Scientometrics* 60, no. 1 (2004): 54

⁶ Scott Frickel and Neil Gross, “A general theory of scientific/intellectual movements,” *American Sociological Review*, 70, (2005): 211.

theories with some variants of the bibliometric approaches advocated by Borgman, Garfield, and Merton, it may be possible to achieve a more holistic picture of power in the scholarly communication system, how it originated, and how it continues to shape the dynamics of academic publishing.

Theories of Scholarly Communication

Sociology of Science and Scientometrics

After defining scholarly communication, Borgman further states that research on scholarly communication includes “the information needs and uses of individual groups, and the relationships among formal and informal methods of communication.”⁷ One of the primary methods Borgman identifies as relevant to the study of scholarly communication is bibliometrics; bibliometrics has traditionally been defined as the application of statistical counting used to analyze the written communications of science.⁸ Borgman further suggests that bibliometric methods are most applicable to the “*formal* channels of scholarly communication, that is, the record of scholarship.”⁹ Much of the literature on scholarly communication has focused on utilizing bibliometric methods to analyze the formal record of scholarship that Borgman outlines.¹⁰ Borgman’s suggestion that bibliometric research is most applicable to formal channels, however, indicates a potential weakness of scholarly communication research as it has often been practiced. How does one understand the informal channels of scholarly

⁷ Christine Borgman, ed. *Scholarly Communication and Bibliometrics*. (Newbury Park, CA: Sage, 1990), 13-14.

⁸ Alan Pritchard, “Statistical Bibliography bibliography or bibliometrics?” *Journal of Documentation*, 25 (1969), 348-349.

⁹ Christine Borgman, ed. *Scholarly Communication and Bibliometrics*, 14.

¹⁰ Christine Borgman, Jonathan Furner, and Blaise Cronin, “Scholarly communication and bibliometrics.” *Annual Review of Information Science and Technology*. 36 (2002), 3-72.

communication? Leah Liverouw has partially answered that question by proposing that further research needs to be done on the “invisible college” which she defines as “a set of informal communication relations among scholars or researchers who share a specific common interest or goal.”¹¹ Lievrouw suggests some quantitative methods, such as network analysis to research invisible colleges.

Sociology of Professions

There is a much larger body of work on the informal structures that professions use, including academic professions. Andrew Abbott, a historical sociologist has defined professionalization “the construction of a knowledge basis for an occupation.”¹² Occupations could consist of law or medicine, or in this case, academic specialties. In the *Chaos of Disciplines* Abbott discusses the particularities that allowed the United States to create a “dual institutionalization” of colleges and universities that created a credentialing system within universities that in turn fed the increasing professionalization of American culture generally.¹³

The kinds of professionalization that Abbott discusses have also been discussed by historians of print culture. In *Print in Motion: The Expansion of Publishing and Reading in the United States, 1880 – 1940*, Janice Radway and Marcel LaFollette discuss the history of professionalization within the context of academic publishing in the United States. Radway suggests that “by disciplining their work and that of the graduate specialists they sought to train,” universities and the professional associations beginning in the late nineteenth century,

¹¹ Leah Lievrouw, “Restructuring Structure and Process in the Study of Scholarly Communication,” in Christine Borgman, ed. *Scholarly Communication and Bibliometrics.*, 59-69 (Newbury Park, CA: Sage, 1990), 66.

¹² Andrew Abbott, “The order of professionalization, an empirical analysis,” *Work and Occupations*, 18, no. 4 (1991): 357.

¹³ Andrew Abbott, *Chaos of Disciplines*. (Chicago: University of Chicago Press, 2001), 125-127.

“professionalized thought, transforming it slowly into a business – the business of knowledge production.”¹⁴ LaFollette argues that scientific publishing had a bi-furcated market within the United States. There was the market for professional academics in which “the intended consumers were the same group of people who produced and evaluated the work” thereby creating an insularity that “encouraged development of an attitude within the research communities whereby scientists claimed ownership of their publication outlets, perceiving the journals and monograph series as ‘theirs,’ even though the intellectual property may have been produced, sold, and copyrighted by the publishers, who bore the financial risk of market failure and reaped much of the profit.”¹⁵ Therefore, according to Abbott, universities first began to professionalize their work in the late nineteenth century; Radway and LaFollette trace the effects of such professionalization on books and journals. This dissertation will combine these two theoretical approaches (sociology of science and sociology of professions) to the study of the scholarly communication system.

Combining Methods

Since there are several areas of interrelated research on the history of professions, universities, and journals, this dissertation by necessity will need to utilize a multi-method approach to investigate the formation of scholarly communication in the U.S. circa 1840 to 1900. Therefore, the dissertation will utilize both qualitative sociological-historical and quantitative computational-statistical approaches to exploring the topic. Most importantly, the dissertation

¹⁴ Janice Radway, “Research universities, periodical publication, and the circulation of professional expertise: On the significance of middlebrow authority.” *Critical Inquiry*, 31, no. 1, (2004): 202.

¹⁵ Marcel LaFollette, “Crafting a communications infrastructure,” 243-244.

will attempt to better understand how professional organizations, universities, academic departments, and scholarly journals interact with each other.

To understand the historical and sociological developments, the dissertation will ask historical questions about why the system formed in the way that it did or who was responsible for creating the social organization of science. These topics are more fully discussed in chapters about Bache and his circle and the American Chemical Society. To comprehend the evolution of journals during this period, this dissertation will utilize topic modeling and other computational and statistical methods on scientific journals of the period to see how some of the more prominent American scientific journals of the mid to late-nineteenth century reflected the mechanisms of control over scholarly associations that scientific leaders like Bache promoted. A review of some of the more prominent journals in the mid-nineteenth century will be represented in the chapter outlining results of topic modeling on the *American Journal of Science*, *Proceedings of the American Association for the Advancement of Science*, and the *Journal of the American Chemical Society*. It is worth noting, however, that these major figures who led journals such as the *American Journal of Science* and organized important scientific societies like the American Association for the Advancement of Science were not the only scientists thinking about the communication of science. There were others, such as Theophilus A. Wylie, a long-serving faculty member at Indiana University and one of Alexander Dallas Bache's students, who had very different ideas. Wylie demonstrates that it was not inevitable for the scientific communication system to develop in the ways that it did. If the scholarly communication practices of Wylie and others like him had taken hold, the system may have looked quite different.

Overall, the goal of this dissertation is to demonstrate that this combination of qualitative and quantitative methods can provide a more nuanced understanding of the origins of the scholarly communication system. This dissertation will also provide a unique approach for modeling how both traditional historical methods and computational techniques such as topic modeling can work together to inform understanding of complex social systems. The sub-discipline of scholarly communication within information science largely relies on quantitative analysis of citation patterns and relies on the sociological theories of scholars such as Robert Merton. This dissertation will employ a broader array of historical and sociological study including the combination of sociology of science, the sociology of professions, and computational topic modeling. This combination of methods will expand the conversation about how social forces shape journals at a time when the scholarly communication in the United States was first beginning.

In the twenty-first century, the scholarly communication system comprises a complex community mechanism encompassing university faculty, scholarly societies, publishers, peer-reviewers, tenure committees, librarians, funding agencies, along with many other actors and an extensive and complex digital infrastructure. According to Christine Borgman, the most essential element of the scholarly communication (or academic publishing) system is the journal article which has remained “remarkably stable and print publication continues unabated, despite the proliferation of digital media.”¹⁶ If current advocates wish to change the scholarly communication system, to make knowledge more available and to embrace the importance of a more truly open system for academic publishing, they must also understand how the journal

¹⁶ Christine Borgman, "Digital libraries and the continuum of scholarly communication", *Journal of Documentation*. 56 (2000), 413.

article became so important and to recognize the scientific power structures governing the production of those articles. These nineteenth-century power structures which led to the current scholarly communication system had very different goals and a very different conception of how research should be shared. The current social barriers to creating a more equitable system of scholarly communication that might include a wider variety of scholars (comprising more marginalized groups) and different kinds of scholarship (beyond long-form arguments such as articles and books) have their origins in a nineteenth-century, industrially oriented publishing organization. Orienting the power of scholarly communication toward a more truly open access system will require a more thorough understanding of its historical development and potential ways for overcoming one hundred years of previous practice.

Literature Review

The history of scholarly communication is a complex story containing many different components. Within information science, the history of science, and the history of education, there have been several histories all with a different emphasis on individual parts of the scholarly communication system. For instance, researchers often have highlighted the importance of academic journals. Yet, the history of journals is only one part of much wider cultural, social, and material mechanisms. Journals are often sponsored by or supported through scientific societies. Additionally, these scientific societies, and the journals they administer, have become recognized by other institutions, including universities, as hallmarks of authority that can be utilized for other mechanisms of advancement such as promotion or tenure. Though there have been many histories of the individual parts of the scholarly communication system (professional societies, journals, and universities), there is still a need for a more thorough integration of these intersecting narratives. This section brings together these interrelated areas of scholarly communication by reviewing the histories of professional societies, journals, and higher education, with particular attention to the situation in nineteenth-century America. Only by taking a more comprehensive view of the closely related areas of professional societies, academic journals, and higher education can we understand the complex origins of the scholarly communication ecosystem in the United States.

The Institutionalization of Science

When discussing the issues of scholarly communication, publisher John Regazzi has traced the long history of academic publishing and argued that the tradition of scholarly periodicals, at least in the English speaking world, goes back to the creation of a single scientific

journal, the *Philosophical Transactions* of the Royal Society in 1667.¹⁷ Though one might quibble with Regazzi's origin point for scholarly communication, he does highlight a key relevant point: the importance of journals. One of the preeminent researchers in scholarly communication, Christine Borgman, has also said that the most essential element of the scholarly communication (or academic publishing) system is the "remarkably stable" journal article that continues to be published despite new technological developments.¹⁸ Borgman's discussion of scholarly communication suggests a broader social system that is also employed in creation of journal articles, and perhaps conference proceedings, books, and other forms of written scholarship. Bruno Latour and Steven Woolgar's work on the social construction of science has already suggested that many elements contribute to the production of the papers that come out of scientific research, "costly apparatus, animals, chemicals, and activities of the bench space combine to produce a written document."¹⁹ Similarly, Marion Blute and Paul Armstrong have written on what they consider the theories of the scientific progression in sociology and concluded that science is both an evolutionary and a social process.²⁰ Therefore, if scientific research and hence the process that produces journal articles is an evolutionary one, perhaps it might be useful to investigate the social origins of the scholarly communication system from which the current structure has developed.

There has already been much work on the origins of scholarly communication in the seventeenth century, particularly in England during the scientific revolution. Steven Shapin,

¹⁷ John Regazzi, *Scholarly Communication: A History from Content as King to Content as Kingmaker*. (New York: Rowman & Littlefield, 2015), 25.

¹⁸ Christine Borgman, "Digital libraries and the continuum of scholarly communication," 413-414.

¹⁹ Bruno Latour and Steve Woolgar, *Laboratory Life: The Construction of Scientific Facts*. (Princeton: Princeton University Press, 1986), 48.

²⁰ Marion Blute and Paul Armstrong, "The Reinvention of Grand Theories of the Scientific/Scholarly Process," *Perspectives on Science*. 19 (2011), 422-423.

writing about the social construction of truth, particularly in science, argues that “seventeenth-century commentators felt secure in guaranteeing the truthfulness of narratives by pointing to the integrity of those who proffered them.... Trust is no longer bestowed on familiar individuals; it is accorded to institutions and abstract capacities thought to reside in certain institutions.”²¹ Other historians including Michael Hunter counter that argument and suggest that organizations such as the Royal Society of London institutionalized to establish a corporate identity separate from individual reputations.²² Rose-Mary Sargent posits a third theory and emphasizes the process of experimental philosophy, or the dialogue between competing scientists, as a basis for creating institutional authority. Such transparent debates, Sargent argues provide a reliance on a process and method for scientific activity that (at least in theory) is understood even by non-scientists.²³ All of these scholars however agree on the importance of the social institutions that underlie scientific endeavors, particularly experiments and the investigation of truth claims. The question of how scientific institutions originated in the American context, rather than the British and European one, however, remains.

Peter Burke in his two-volume book - *A Social History of Knowledge* has gone so far as to lament that there is “a still unwritten history of specialization.”²⁴ Burke identifies the necessary components of such a history. In his discussion of “societies, journals and congresses,” when he discusses the United States context, Burke argues that “there was a new wave in the latter nineteenth century associated with the separation of disciplines and

²¹ Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England*. (Chicago: University of Chicago Press, 1994), 411.

²² Michael Hunter, *Establishing the New Science: The Experience of the Early Royal Society*. (Woodbridge: The Boydell Press, 1989), 2 – 3.

²³ Rose-Mary Sargent, *The Diffident Naturalist: Robert Boyle and the Philosophy of Experiment*. (Chicago: University of Chicago Press, 1995), 205.

²⁴ Peter Burke, *A Social History of Knowledge: From the Encyclopédie to Wikipedia*. (Cambridge, UK: Polity Press, 2012), 161.

departments.”²⁵ The disciplines to which Burke refers are the professional “congresses” or associations that were forming at the time; the departments are the university governance structures that were simultaneously developing along with the scientific associations and their related journals. Therefore, at least according to Burke, in order to understand the origins of the scholarly communication system in the United States, one needs to understand three separate, but highly interconnected histories, that of professional associations, universities, and journals.

Professional Societies and Universities

Historical literature discussing the development of professions and universities in the United States (and in other countries, principally the U.K. and Germany) is particularly well developed. This body of scholarship, however, is also extremely complicated to examine because of its inherent interdisciplinarity. Sociologists, including those who have a historical focus, have written quite extensively on theories of professionalization over time and the necessary stages in which professional evolution occurs. On the other hand, historians interested in the development of professions have tended to concentrate on individual case studies including specific scientific institutions or professional associations. Rarely do these two bodies of literature, though highly interconnected, overlap.

Therefore, if one is to study the history of professionalization, it is important to have an understanding of both the general theories that sociologists have put forward, especially those sociologists interested in the historical evolution of professions, and also to comprehend how the individual case studies, predominantly those related to nineteenth-century U.S. science (the area on which I am focusing) reflect these broader sociological theories. Additionally, though

²⁵ *Ibid*, 166.

historical sociologists have tended to concentrate primarily on the nineteenth and twentieth centuries, historians have studied the concept of professionalization as it developed over at least the past five hundred years. Thus, there is a widely divergent body of literature discussing the development of professions, and the literature of both the history of professionalization and the sociology of professions have something to contribute to the understanding of professional scientific associations. Understanding how these two areas complement each other is especially important in studying the history of scholarly communication, since professional associations are such an important part of the academic publishing ecosystem.

Theories of Professionalization

Much of the theory regarding professionalization comes from the field of sociology. There are three particularly relevant areas with regard to scholarly communication. The first of these is the sociology of science, represented best by the work of scholars like Robert Merton. The second is the work of historical sociologist Andrew Abbott, who has investigated the development of the medical and legal professions, though with some interest in science and education as well. Finally, there is the work of Scott Frickel and Neil Gross, whose work has focused on the influence of social movements on scientific professions; the work of Frickel and Gross serves as an excellent supplement to the work of scholars like Abbott. Merton, Abbott, and Frickel and Gross demonstrate three distinct but related approaches for understanding professionalization in the sciences.

The first, and perhaps most well-known of these areas to scholars in the field of scholarly communication is the sociology of science. Though there are of course many scholars interested in this field, much of the underlying theory rests on the work of two foundational scholars: Thomas Kuhn and Robert Merton. Kuhn focuses quite broadly on the evolution of scientific

systems over time through his concept of “paradigms” or the systems by which scientists understand the world.²⁶ Robert Merton concentrated on the values of the modern scientific system and the methods individual scientists utilized to achieve status within their profession.²⁷ Both Kuhn and Merton are cited extensively within the sociology of science; however, Robert Merton has achieved a particularly important status for scholars studying the structures of scholarly communication. For example, Cassidy Sugimoto in her *Introduction to the Theories of Informetrics and Scholarly Communication* has said that “Many theories have been imported from other disciplines to describe patterns and phenomena within informetrics and scholarly communication.... Robert Merton’s body of work is a ready example of this. With the exception of Blaise Cronin, Merton is cited more in this volume than any other author and his theories are used as the foundation for empirical studies.”²⁸ Though the field of scholarly communication certainly utilizes Kuhn, much of the social dynamic that Kuhn tries to explain is not as explicit in the literature on the structure of scholarly communication, perhaps because of that body of literature’s reliance on Merton’s work.

There is also a body of scholarly work within science and technology studies that utilizes Kuhn in order to discuss the process of scholarly discourse. Marion Blute and Paul Armstrong suggest that the production and dissemination of knowledge is primarily sociological including issues such as “the social nature of science/scholarship—internal versus external, progress, the role of competition and constructionism.”²⁹ Blute and Armstrong’s analysis of the scholarly process, draws on several theorists within the history and sociology of science including both

²⁶ Thomas Kuhn, *The Structure of Scientific Revolutions*. (Chicago, IL: University of Chicago Press, 1970).

²⁷ Robert Merton, *Social Theory and Social Structure*.

²⁸ Cassidy R Sugimoto, ed, *Theories of Informetrics and Scholarly Communication*, (Boston: De Gruyter, 2016), 2.

²⁹ Marion Blute and Paul Armstrong, “The reinvention of grand theories of the scientific/scholarly process,” *Perspectives on Science*, 19, no. 4 (2011): 394.

Andrew Abbott and Scott Frickel. Additionally, the work of Stephan Fuchs, drawing widely from the work of both Thomas Kuhn and Randall Collins, has discussed methods in which hermeneutics and language have affected the techniques by which scientific organizations produce knowledge.³⁰ According to Fuchs, scientists with respect to their work in scientific societies “will engage in hermeneutics and conversation rather than science and fact production as long as the structure of our profession remains loosely organized.”³¹ In other words, when professions are less structured, often in their earlier years, communication patterns are more loosely designed and practitioners engage in broader conversations that do not lead to organized fact production. On the other hand, when the professions become more controlled, methods of communication become more formal and more bureaucratized; such formal structures allow scientists and other professionals to directly contribute to more well-defined fact producing forms of communication. Timothy Lenoir also offers some more historically situated criticism, particularly of Merton, by arguing that any “account of science and its institutions I wish to offer is situated within other traditions of sociology, cultural history, and philosophical reflections on the foundations of knowledge.”³² Thus for Lenoir, sociological theory must be situated within a particular historical and philosophical context.

One of many sociologists who have shown sensitivity to the context Lenoir mentions is Andrew Abbott, a historical sociologist, who has written extensively on professionalization, and provides several relevant frameworks to understand institutionalization of work within

³⁰ Randall Collins, *The Sociology of Philosophies: A Global Theory of Intellectual Change*, (Cambridge, MA: Belknap Press of Harvard University Press, 1998).

³¹ Stephan Fuchs, *The Professional Quest for Truth: A Social Theory of Science and Knowledge*. (Albany, NY: SUNY Press, 1992), 215.

³² Timothy Lenoir, *Instituting Science: The Cultural Production of Scientific Disciplines*. (Stanford, CA: Stanford University Press, 1997), 8.

professional associations. In many ways, the patterns Abbott notices are in line with much of the historical literature about the professionalization of science. Abbott has even written about the approaches academic institutions and disciplines have used to establish themselves, and he has done so with attention to historical development over time. Abbott's work on the formation of professions has also focused extensively on the U.S. in the nineteenth century, and therefore can also help in analyzing the professionalization of scientific organizations in nineteenth-century America.

One of the more comprehensive frameworks Abbott has constructed was published in "The order of professionalization." In this article Abbott defines professionalization primarily as an intellectual phenomenon in which its "central tasks ... lie in the construction of a knowledge basis for an occupation."³³ Such construction occurs through a multi-tiered framework that contains at least three levels of activity: national, state, and local. Abbott stresses the importance of creating educational institutions (such as schools and universities). Yet, Abbott also notes that these activities can happen independently of and concurrently with the three levels of professionalization that he defines. Abbott argues that there are four basic elements that run through all of these levels of professionalization: association (groups of people forming to meet a particular need either for a small localized problem or for a national and more complicated issue), control of work (or ways of making sure that only people who understand the issues involved are working on the problem), education (ensuring that this knowledge gets passed on effectively, usually through some school), and knowledge (the most complex of the elements usually consisting of journal or other publications like directories or manuals). These elements of knowledge administration vary depending on whether one is looking at the local, state, or

³³ Andrew Abbott, "The order of professionalization, an empirical analysis," 357.

national levels and interact with each other substantially. Though Abbott's historical examples focus primarily on the medical field, the constructs are broad enough that they could easily be applied to other areas of practice. Most importantly, in his conclusion Abbott states that professionalization is "a complex dynamic process with several levels of action." It is not a "simple collective action by a cohesive group, and we cannot discuss it as if it were."³⁴

Abbott has applied this overall framework to the context of academic disciplines in various ways. In *Chaos of Disciplines* and *The System of Professions* he suggests that there is a unique combination of forces that shapes academic professionalization. The *Chaos of Disciplines* argues that national forces within the United States created a particular dynamic or "dual institutionalization" of colleges and universities that created the "extraordinary resilience of the American system of academic disciplines." First, Universities were numerous and decentralized, faculty employment was expanding, and newly-forming professions began to view college degrees as a qualification for further professional schooling such as law or medical degrees. Concurrently, professional associations in fields were also beginning to form. Therefore, since professions viewed undergraduate majors as a prerequisite for further studies, and since academic disciplines formed into professional societies, disciplinary/professional structures began to replicate themselves throughout the system of undergraduate education in the United States.³⁵ In the *System of Professions* Abbott provides some numbers demonstrating those trends. In 1900 only 2% of twenty-three-year-olds received an undergraduate degree, and 6% of those graduates went on to receive another professional degree. By 1970 that number had

³⁴ *Ibid*, 3.

³⁵ Andrew Abbott, *Chaos of Disciplines*, 125-127.

increased to 25% of twenty-three-year-olds receiving an undergraduate degree and 33% of those graduates receiving a further professional degree.³⁶

There are two particularly important points within Abbott's analysis of these social forces driving the formation of academic professions. First, he stresses the symbiotic relationship between universities and academic disciplinary structures. These ideas are explained more thoroughly in his article "Linked ecologies: States and universities as environments for professions." Second, Abbott suggests that professions valued "pure" knowledge that is often theoretical but at the very least is free of most professional side issues. Both of these concepts are important in understanding how academic disciplines perpetuated themselves over time.

In "Linked ecologies," Abbott focuses on disciplines such as social work, medicine, and the law. Nonetheless his ideas are also applicable to academic disciplines because individuals within scientific specializations also act in ways very similar to other professions. Abbott's argument focuses on the idea that ecosystems in nature often have interdependencies and linkages between them. He goes on to apply this analogy to social systems. For instance, a profession like medicine may have linkages between the society and governmental organizations, universities, state and local credentialing authorities, individual hospitals, and other professional societies. Abbott stresses that when dealing with small numbers of such groups, his analogy works quite well, but when the number of linkages grows too large (such as in the military) then there are so many organizations involved that his analogy begins to break down. Abbott suggests that an individual ecology has several characteristics. First it has defined boundaries and claims particular understanding over a particular domain of knowledge (such as healing

³⁶ Andrew Abbott, *The System of Professions: An Essay on the Division of Expert Labor*. (Chicago: University of Chicago Press, 1988), 209-210.

medical problems or scientific methods for understanding certain phenomena). Second, when there is overlap between ecologies or areas where discrepancies arise, ecologies form a “hinge” in which the two ecologies either cooperate or find a way to resolve the discrepancy.³⁷ For example, though Abbott does not discuss this example in the linked ecologies article, the cooperation between disciplinary societies and universities that Abbott described in *System of Professions* and *Chaos of Disciplines* might be described as a hinge. In that case, two ecologies (professional societies and universities) created a linkage that allowed universities to accredit students so that they could enter professions (often through further education).

In *Chaos of Disciplines* Abbott argues that the professionalization of disciplines follows a trend common to many professions that “organize around abstract knowledge, and, like any social structure, they tend to grant prestige to those most closely associated with their organizing principles – those who exercise the professions’ knowledge in its most pure form.”³⁸ In other words the most prestigious professionals study theoretical, rather than practical subjects. Abbott discusses this idea of the “purity” of professional knowledge more thoroughly in “Status and status strain in the professions” where he argues that (at least within the medical profession) the purest knowledge and the highest status professionals have “an ability to work chiefly with problems from which not only the general impurities but also a number of professional side issues have been ruled out.”³⁹ The example he discusses is a mitral valve surgeon who sees a patient who has already been referred by a general practitioner, an internist, and a cardiologist; so there is no doubt that the problem is with the mitral valve. Similarly, in *Chaos of Disciplines*

³⁷ Andrew Abbott, “Linked ecologies: States and universities as environments for professions.” *Sociological Theory*, 23, no. 3 (2005): 245-274.

³⁸ Andrew Abbott, *Chaos of Disciplines*, 145.

³⁹ Andrew Abbott, “Status and status strain in the professions,” *American Journal of Sociology*, 86, no. 4 (1981): 827.

Abbott argues that, “neurologists and cardiologists stand above family-care physicians, since they work as consultants and hence are more purely medical” and professionals who do what the public imagines them to be doing (such as physicians seeing patients) are actually considered of low status. Abbott applies this same concept to university professors by saying “professors give highest prestige to people who do as little teaching [what most people probably imagine professors doing] as possible... In short, academics, like other professionals, are subject to a ‘regression’ into professional purity.”⁴⁰ Abbott defines professional purity as mastery of a very particular domain of knowledge that is untainted by more generalized or more practical concerns of an individual profession or members of the general public.

All of these ideas from Abbott provide some general contours of professionalization, particularly within academe, but one important question remains. How might any of these ideas help to situate professionalization in a historical context? In “Things of boundaries” Abbott gives some clues about how to use historical examples with his larger theories. Generally, this work is about techniques that professions develop to replicate themselves: “our ideal type of occupation includes three things: a particular group of people, a specific type of work, and an organized body or structure, other than the workplace itself, capable of reproduction.”⁴¹ Abbott specifically discusses how historically this replication has happened and discusses the idea of historical causation, or the idea that certain events (such as meetings or gatherings of these individuals) lead to a consequence, like the formation of a national organization.

However, Abbott’s discussion of this causation is somewhat vague. He states that people construct historical narratives “from back to front. We start with what we know emerged and

⁴⁰ Andrew Abbott, *Chaos of Disciplines*, 146.

⁴¹ Andrew Abbott, “Things of boundaries,” *Social Research*, 62, no. 4 (1995): 873-874.

then seek its origins. But history is lived from front to back. Things emerge not from fixed plans, but from local accidents and structures.”⁴² Abbott goes on to discuss the origins of social work and the way in which local charities, governments, and educational foundations met in order to discuss common problems, and eventually those informal and unorganized groups formed into professional societies comprised of members from these charities and government agencies, and eventually these formalized societies credentialed professional social workers. Though Abbott repeatedly stresses that local accidents and less than methodical approaches cause further events to happen, leading to professional organization, he does not go into detail about whether there are any general characteristics that are common to the development of professional organizations. Is the development of all professional organizations merely accidental, or are there common evolutionary stages through which professional organizations form, particularly in the sciences?

The work of Scott Frickel and Neil Gross may help to answer these questions and to further supplement many of Abbott’s theories. In their article “A general theory of scientific/intellectual movements” they explain the process by which academic disciplines progress from an initial formation event to a national organization. Focusing on Scientific and Intellectual Movements (SIMs) - such as the development of Pragmatist philosophy in the nineteenth century or the Chicago school of Sociology in the twentieth century - Frickel and Gross draw on a variety of scholars, including Abbott, to create a general theory for what they argue are the central mechanisms for change within organizations focused on knowledge and ideas. Several of the components within this general framework help to supplement Abbott’s work on professionalization. First, Frickel and Gross suggest that SIMs tend to come into focus

⁴² *Ibid*, 865.

when high powered and prestigious intellectual leaders help to facilitate the formation of a SIM. Second, Frickel and Gross stress that SIMs respond to outside political pressures that happen within a national or even international context. In other words, unlike the professional organizations that Abbott discusses, which need to respond primarily to local conditions, SIMS do not have such local demands and tend to respond to pressures in a much broader context. Third, Frickel and Gross suggest that SIMS are inherently “political” in their nature. Political by Frickel and Gross’s definition is Weberian,⁴³ meaning they rely on Max Weber’s theories regarding the distribution and implementation of power. Therefore, in Frickel and Gross’s view, unlike professions such as medicine or law, SIMs have a power dimension that is not necessarily present in the professional examples that Abbott discusses. Finally, Frickel and Gross stress the historical dimension to SIMs that inevitably claims an inheritance from broader social movements and supplement some of the vaguer assertions on stages of historical development mentioned by Abbott.

This historical sensibility connects Frickel and Gross particularly well to Abbott, and even to historians of science. In order to make their case regarding how SIMs create a historical narrative, Frickel and Gross draw on Abbott’s work *The Chaos of Disciplines* and *Department and Discipline*. In those works, Abbott does discuss academe as a part of broader professionalization effort. In particular, Frickel and Gross draw from Abbott’s examples of the Chicago School of sociology because “it became important for Chicago sociologists to develop a ‘cohesive ideology’ . . . by situating themselves in an intellectual tradition they helped to

⁴³Max Weber, “Politics as a Vocation.” in *From Max Weber: Essays in Sociology*, edited by H. H. Gerth and C. W. Mills, 77–128. New York: Oxford University Press, 1946.

invent.”⁴⁴ Such historical contextualization, Frickel and Gross argue, helps to situate SIMs in relation to their competitors within academic disciplines such as sociology, which, in addition to the Chicago School, included Marxist sociology and the Columbia school.

One of the initial ways that a SIM begins to set itself apart is through the actions of a single prestigious individual within the field. Abbott discusses the inaugural event that helps to form a profession but does not specifically address how such an event might occur. Frickel and Gross elaborate on the “catalyst” for the formation of a profession by drawing on Kuhn to argue that dissatisfaction with a particular framework causes individuals to seek new ways to deal with problems. Frickel and Gross further draw from the work of Robert Merton to suggest that SIMs harness such dissatisfaction with the status quo through an influential figure within the field.

Such prominent figures often respond to outside forces on a much broader level and not just to the professional needs that Abbott addresses. Frickel and Gross suggest that “SIMs are influenced by direct or indirect pressures emanating from the broader cultural and political environment.”⁴⁵ Such pressures could include government, industry, education systems, or social movements. Importantly it is these broader forces that allow SIMs to develop on a national or international level without necessarily developing the local infrastructures that Abbott discusses in relation to other professions.

Finally, Frickel and Gross supplement Abbott’s theories by demonstrating the politicization (in a Weberian sense) of SIMs. Drawing on the work of Randall Collins and Pierre Bourdieu,⁴⁶ Frickel and Gross suggest that, “precisely because the intellectual practices

⁴⁴ Scott Frickel and Neil Gross, “A general theory of scientific/intellectual movements,” *American Sociological Review*, 70, (2005): 224.

⁴⁵ Scott Frickel and Neil Gross, “A general theory of scientific/intellectual movements,” 209.

⁴⁶ Pierre Bourdieu, *Homo Academicus*. (Stanford, CA: Stanford University Press, 1988).

recommended by SIMs are contentious, SIMs are inherently political.”⁴⁷ Additionally, Frickel and Gross argue that these political differences are driven not only by the desire to achieve prestige (as Merton argues), but are also a product of other motives. Most importantly, individuals within SIMs wish to determine which people and groups retain authority and power over the movement, and how such power and authority is distributed within a particular SIM. In all, Frickel and Gross utilize a wide variety of sociological theories that help to supplement much of Abbott’s framework on professionalization, particularly within the context of a SIM.

Histories of Professionalization

Many of these broader theories about professionalization of science are rarely discussed in historical studies of professions. Generally, histories of professionalization have tended to be more narrowly focused on case studies and less interested in creating generalizable theories. Nonetheless, there is at least one exception. In a short article titled “The Process of Professionalization in American Science: The Emergent Period, 1820-1860;” George Daniels, better known for his work on science in Jacksonian America, attempts to answer questions about the development of professions, particularly in the sciences.⁴⁸ Daniels’ article has been utilized in some interesting ways by other scholars. The article is cited by historians, sociologists studying the Scopes Monkey Trial,⁴⁹ and by legal scholars tying together models of professional education in the sciences and law.⁵⁰ Daniels himself suggests that the model he puts forward is a simplification. Yet this simplification provides a starting point for thinking about general

⁴⁷ Scott Frickel and Neil Gross, “A general theory of scientific/intellectual movements,” 207.

⁴⁸ George H. Daniels, “The Process of Professionalization in American Science: The Emergent Period, 1820-1860,” *ISIS*, 58, no. 2 (1967), 150-166.

⁴⁹ Thomas F. Gieryn, George M. Bevens, and Stephen C. Zehr, “Professionalization of American Scientists: Public Science in the Creation/Evolution Trials.” *American Sociological Review*, 50, no. 3 (1985): 393.

⁵⁰ Howard Schweber, “The ‘Science’ of Legal Science: The Model of the Natural Sciences in Nineteenth-Century American Legal Education.” *Law and History Review*, 17, no. 3 (1999): 435.

patterns in scientific professionalization and how such patterns may differ from some of the sociological theories about more recent professional occupations.

Daniels posits that there are four stages to the professionalization of science during the nineteenth-century. The first is “preemption” when what had once been the domain of a large body of generalists becomes too complex and therefore becomes the exclusive domain of a group of specialists with a deeper understanding of a particular subject area. The second stage is “institutionalization” when these groups of specialists begin to structure their behavior and regularize relationships among themselves. The third stage is “legitimation” which requires that these established institutions justify themselves to the general public. Professionals often do this by making a claim that they are creating “pure” knowledge and are returning positive benefits to society in some way. Finally, professional scientific organizations seek, according to Daniels, the “attainment of professional autonomy” when a scientific profession is generally accepted both among other scientists and within society at large.⁵¹

According to Daniels, these stages of professionalization often overlap, and more importantly, are part of a constant compromise between the professionals themselves, other groups vying for the same scientific authority, and the public. Therefore, the relationships among these groups are constantly changing, shifting, and evolving. Historians of course are not the only scholars who have thought about the formation of professions. Though understanding some general patterns of professionalization in nineteenth century America is certainly helpful, there are still some open questions. How are the sciences different from other professions? Are there general patterns shared by science and other professions? Additionally, if historians of

⁵¹ George H. Daniels, “The Process of Professionalization in American Science: The Emergent Period, 1820-1860,” *ISIS*, 58, no. 2 (1967), 150-166.

scientific professionalization want to make any connections between the origins of scientific organization and its current developments, how do these early foundations influence the evolution of science?

Unfortunately, historians have not engaged with these general questions very often. Most historical work on professionalization has focused on small narratives within a much larger story of scientific professionalization during the past several hundred years. There have, however, been a few studies that have focused on the professionalization of science more generally. Tore Frangsmeyer edited a volume, largely based on a symposium about the institutionalization of science, on the myriad of ways that science has organized itself beginning with academies like the Royal Society of London and extending into universities, industries, governments, and many other institutions.⁵² The work, though valuable, summarizes much of the research that others have done already on various scientific organizations, and focuses more on Europe than on the United States. Steven Shapin, looking from the point of view not of institutions but of individual scientists, has written a history of scientists and how they have reacted to the changing social situations in which they have lived. Shapin concludes that there are two basic ways of interpreting scientific activity: instrumental and phenomenological. Shapin defines instrumental as, “ironical (things are not what they *seem*)” and phenomenological as, “concerned about *seeming* as part of the interaction order.”⁵³ For Shapin, it is important to apply both of these approaches to research within the history either of scientists or of scientific institutions.

⁵² Tore Frangsmeyer, ed. *Solomon's House Revisited: The Organization and Institutionalization of Science*. Canton, MA: Watson Publishing International, 1990.

⁵³ Steven Shapin, *The Scientific Life: A Moral History of a Late Modern Vocation*. (Chicago : University of Chicago Press, 2008), 312.

There has also been some scholarly work focused less broadly than that of Frangsmeyer or Shapin, but more generally than an individual case study. David Cahan has edited a volume on nineteenth-century science in which scholars of individual disciplines such as chemistry, physics, or biology have written about the development of individual scientific fields. Cahan stresses that it is important to look at the development of science from a generalized “natural philosophy” to the more specific disciplines that have become prevalent in the modern world. Cahan also writes his own chapter about the institutionalization of science in which he laments that there has been a “relative (and nearly absolute) lack of systematic and concerted attention to institutions and communities” within the history of science.⁵⁴

Though Cahan’s assertion is largely true, there has been a fair amount of research on the history of science in the United States during the nineteenth century. Nathan Reingold edited two volumes consisting of many case studies, and he noted three characteristics of the history of science, especially during the nineteenth century in the United States. First, Reingold suggested that “fairly pervasive is an interest in applied fields.”⁵⁵ Second, Reingold believed that at least prior to the twentieth century, American scientists were “overwhelmingly a middle-class group” coming from similar socio-economic groups. Finally, unlike Europe, American scientists perceived themselves as having few great figures or movements similar to what was happening in Europe.⁵⁶ Alexandra Oleson and John Voss add another characteristic of nineteenth-century American science to those that Reingold mentions. They suggest that “American institutions of

⁵⁴ David Cahan, “Institutions and Communities” In *From Natural Philosophy to the Science: Writing the History of Nineteenth-Century Science*, edited by David Cahan, 291-328. (Chicago: University of Chicago Press, 2003), 291.

⁵⁵ Nathan Reingold, “Introduction,” In *Science in America Since 1820*, edited by Nathan Reingold,. 1-6. (New York: Science History Publications, 1976), 3.

⁵⁶ Nathan Reingold, “Reflections on 200 Years of Science in the United States,” In *The Sciences in the American Context: New Perspectives*, edited by Nathan Reingold,. 9-20. (Washington, D.C.: Smithsonian Institution, 1979), 16.

learning, linked to industrial corporations, also have been seen as part of a trend toward nationally oriented, impersonal, hierarchical organizations.”⁵⁷ These general characteristics are also reflected in the many individual case studies, some of which are chapters within these broader volumes edited by Reingold, Oleson, and Voss.

Though these general histories of scientific institutions and scientists have been utilized by historians, still the majority of scholarship consists of case studies either of individuals or of particular scientific organizations. The scholars who have focused on some of the earliest professional societies such as the Royal Society of London in the mid-seventeenth-century have emphasized the collaborative aspects of early modern scientists and the organizations of which they were a part; in order to practice good science, researchers of seventeenth-century science have argued that it was essential for these early scientists to share results and to compare observations with other scientists.⁵⁸ Yet, early modern scientists also acted within certain social contexts. For England, Steven Shapin has investigated the methods “gentlemen” used to dominate the scientific class within the Royal Society, and even experimental philosophy more generally.⁵⁹ Mario Biagioli has looked at similar questions though from a broader European perspective, and has examined the social norms and etiquette in which these scientists practiced.⁶⁰ Still other scholars, like Peter Burke, have suggested that scholarly journal publication is simply one part of a larger trend in reading practices during the late seventeenth

⁵⁷ Alexandra Oleson and John Voss, “Introduction,” In *The Organization of Knowledge in Modern America, 1860-1920*, edited by Alexandra Oleson and John Voss, vii-xxii. (Washington, D.C.: Smithsonian Institution, 1979), xix.

⁵⁸ Brian Ogilvie, *The Science of Describing: Natural History in Renaissance Europe*. (Chicago: University of Chicago Press, 2006), 63-86.

⁵⁹ Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England*. (Chicago: University of Chicago Press, 1994), and Steven Shapin and Simon Schaffer, *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life*. (Princeton, NJ: Princeton University Press, 1985).

⁶⁰ Mario Biagioli, “Etiquette, Interdependence, and Sociability in Seventeenth-Century Science,” *Critical Inquiry*, 22 (1996): 193-238.

and early eighteenth century, and journals such as *Philosophical Transactions* are simply a small part of much broader trends in periodical publishing.⁶¹

Some of these seventeenth-century English conceptions of sociability and sharing continue in the American historical context during the eighteenth century. John Greene in an article discussing the organization of science in eighteenth century Philadelphia acknowledges that Philadelphia was a center of American scientific scholarship, because of its large population that contained a large number of potential scientists, and, more importantly, because Philadelphia could economically support more institutions dedicated to science. American science did however have one major difference from its European counterparts, a dedication to “promoting useful knowledge, with a heavy emphasis on practical utility” which has its origins in both the original aims of the Royal Society of London and in Benjamin Franklin’s emphasis on practical knowledge as the basis of America’s first learned society, the American Philosophical Society.⁶² Much of the scholarship written about American professional scientific societies has focused on specific organizations, mostly in the nineteenth century, and was performed in the 1970s. This body of scholarship tends to focus on certain societies, the most comprehensive of which is Sally G. Kohlstedt’s work on the American Association for the Advancement of Science (AAAS). Kohlstedt emphasizes that there was a tension between “amateur” scientists and the need for professional specialists who could aid industrial activities throughout the early to mid-nineteenth century, and though the AAAS attempted to navigate these tensions, the organization never took a firm stand on these issues. As a result, the AAAS lost some of its influence in the late

⁶¹ Peter Burke, *A Social History of Knowledge: From Gutenberg to Diderot*.

⁶² John C. Greene, “Science, Learning, and Utility: Patterns of Organization in the Early American Republic,” In *The Pursuit of Knowledge in the Early American Republic: American Scientific and Learned Societies from Colonial Times to the Civil War*, edited by Alexandra Oleson, and Sanborn C. Brown, 1-20. (Baltimore: Johns Hopkins University Press, 1976), 3.

nineteenth century to more specialized groups (such as the American Chemical Society).⁶³

Perhaps more importantly, Kohlstedt maintains that the AAAS did attempt to set standards for science within the United States and to protect against less rigorous scientific methods. Though the AAAS may not have been successful in this regard, it did provide a platform for its sections (like the one in Chemistry) to begin to set standards for smaller scientific communities, and eventually to form more rigorous standards among smaller groups of practitioners.⁶⁴

Kohlstedt's studies are far from the only such case study of professional associations in the nineteenth century, however. In 1976 Alexandra Oleson and Sanborn C. Brown edited a volume on "American Scientific and Learned Societies" that focuses not only on large national organizations like the AAAS, but also on much smaller local groups around the United States. In that volume, Nathan Reingold in a more general essay on the professionalization of science suggests that in the nineteenth century there were three types of "scientists" including researchers (those who were publishing in scientific journals and employed in science-related occupations), practitioners (those employed in science-related occupations but not publishing), and cultivators (those for whom science was an avocation rather than a profession).⁶⁵ Reingold's model of scientific professionalization largely follows an earlier model discussed by Steven Shapin and Arnold Thackeray in the British Context.⁶⁶ Reingold's observation reflects many of

⁶³ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 232-233.

⁶⁴ Sally Gregory Kohlstedt, Michael M. Sokal, and Bruce V Lewenstein, *The Establishment of Science in America: 150 Years of the American Association for the Advancement of Science*. (New Brunswick, N.J., Rutgers University Press, 1999), 48-49.

⁶⁵ Nathan Reingold, "Definitions and Speculations: The Professionalization of Science in America in the Nineteenth Century," in *The Pursuit of Knowledge in the Early American Republic: American Scientific and Learned Societies from Colonial Times to the Civil War*, edited by Alexandra Oleson, and Sanborn C Brown. (Baltimore, MD: Johns Hopkins University Press, 1976), 31-34.

⁶⁶ Steven Shapin and Arnold Thackeray, "Prospography as a Research Tool in History of Science: The British Scientific Community, 1700-1900," *History of Science*, 12, no. 1 (1974): 12-13.

the tensions that Kohlstedt notes, however. In the same way that researchers, practitioners, and cultivators were vying for authority among themselves, researchers and practitioners were also competing for control within scientific organizations such as the AAAS.

A second type of scholarship on professionalization of science in the nineteenth century utilizes many of the same ideas as the institutional forms of scholarship exemplified by scholars such as Kohlstedt and Reingold. Burton Bledstein ties “professionalism” to both universities and the rise of an industrial middle class in the nineteenth century. Bledstein suggests that trends such as an increasing number of professional occupations caused by American industrialization, a need for more professional education in universities, and a growing culture among American citizens linking their occupations to such employment within particular professions and education was all part of “the professionalization of American lives” that “manifested itself everywhere, in popular culture, the academy, and spectator sports, indeed in the ordinary habits of a middle-class life.”⁶⁷ Therefore, Bledstein sees science as an occupation tied strongly to other similar professions such as law and medicine as a part of nineteenth-century American life.

Whereas Bledstein looks primarily at social life among Americans, Robert Bruce in *The Launching of American Science* investigates a more unique aspect of American life, growing bureaucratization and government influence, especially after the American Civil War. Bruce focuses more on the institutions that science created during this period, particularly associations like the AAAS, and government-sponsored institutions such as the Smithsonian and the National Academy of Science. Such institutions are often led by a small group of individuals, and Bruce shows an interest in one man, Alexander Dallas Bache, who is often credited as the architect of

⁶⁷ Burton J. Bledstein, *The Culture of Professionalism: The Middle Class and the Development of Higher Education in America*. (New York: W. W. Norton, 1976): 80.

American science. Bruce quotes one of Bache's enemies who said "He [Bache] is laboring with all the powers of a Jesuitical mind of no mean order to attain scientific reputation."⁶⁸ Because of Bruce's focus on such a small group of individuals (largely those who were supportive of, or opposed to, Bache), Bruce concludes his arguments by stating that despite a growing number of people involved in scientific pursuits in the United States there came to be a kind of aristocracy among scientists so that "in science even more than in technology, the advance of specialization and complexity was leaving the public behind."⁶⁹ In all, organizers of science like Bache created a hierarchical system of science that greatly impacted the future of scientific organizations.

Such a focus on seminal figures like Bache exemplifies the final type of historical work on professionalization of science: biographies of important figures, most notably Bache himself. Axel Jansen has written a biography in which he specifies that he is writing about Bache's career as a scientist rather than a comprehensive biography. Jansen concludes his book by calling for a new paradigm for investigation of nineteenth century science as a profession. Jansen, like Bruce, argues that Bache was insistent on creating a sort of aristocracy within American science because Bache was attempting to create a universal culture of science within the United States and that Bache desired above all for science in the United States to form a national, rather than a local, character. For Bache, American progress must be tied to scientific advancement, hence his interest in creating organizations like the AAAS and the National Academies.⁷⁰

Other historians have also focused on Bache's influence over the organization of science, predominantly through his patronage as a government official within the United States Coastal

⁶⁸ Robert Bruce, *The Launching of Modern American Science 1846-1876*. (New York: Alfred A. Knopf, 1987), 174.

⁶⁹ *Ibid*, 356.

⁷⁰ Axel Jansen, *Alexander Dallas Bache: Building the American Nation Through Science and Education in the Nineteenth Century*. (New York: Campus Verlag, 2011), 322-324.

Survey (the largest scientific and government funded national organization in the mid-nineteenth century). Hugh Richard Slotten, drawing on the work of Thomas Gieryn,⁷¹ argues that Bache himself used his networks of professional scientists to create very clear boundaries between Bache's own version of science and other science less important to him. As a result of this boundary work, Bache was able to create something similar to a scientific aristocracy that positioned him at the center of both patronage and social acceptance.⁷² In some ways, Slotten's stress on the importance of sociability and social reputation in American scientific circles, is very similar to the arguments that Steven Shapin made about seventeenth century science in England, though in a completely different cultural and social context (Britain versus the United States).

It should also be noted that the study of nineteenth-century American science has not necessarily been limited only to natural sciences like chemistry or physics. The social sciences have also been a focus of research on the professionalization of science in the United States. Thomas Haskell in *The Emergence of Professional Social Science* has approached many of the same issues as historians of the natural sciences, but from a completely different angle. Haskell approaches the social sciences from the perspective of determining authority. Haskell argues that at least in the nineteenth century, other sciences developed an ideology of positivism that allowed them to become unified in a way that the social sciences never did. He classifies social scientists as "anti-formalists, suspicious of all attempts to abstract from the flux of reality – for abstraction is a process of isolation."⁷³ As a result of this differing stance on authority, the social

⁷¹ Thomas F. Gieryn, "Boundary-Work and the Demarcation of Science from Non-Science: Strains and Interests in Professional Ideologies of Scientists," *American Sociological Review*, 48, (1983): 781-795.

⁷² Hugh R. Slotten, "The Dilemmas of Science in the United States: Alexander Dallas Bache and the U.S. Coast Survey," *ISIS*, 84, no. 1, (1993): 43-44

⁷³ Thomas L. Haskell, *The Emergence of Professional Social Science: The American Social Science Association and the Nineteenth-Century Crisis of Authority*. (Urbana, IL: University of Illinois Press, 1977), 254.

sciences never rose to the same prominence as many of the other sciences and never achieved the same status as other scientific disciplines.

A final category of scholarship within nineteenth-century American science is what might be termed institutional histories of individual fields and organizations that are quite similar to the histories of the AAAS. The membership of the Franklin Institute of Philadelphia, such as Alexander Dallas Bache, largely overlapped with the membership of other important scientific organizations at the time. Additionally, the Franklin Institute emphasized practical aspects of economic development, but did not stress professional recognition and development, such as one might normally associate with current professional organizations.⁷⁴ Overall, the history of the Franklin Institute mirrors some of the individual histories of other professional organizations.

In addition to organizations like the Franklin Institute, one discipline, chemistry, has been intensely cognizant of its history, and the American Chemical Society (ACS) commissioned a *History of the American Chemical Society* by Charles Browne and Mary Weeks published for the ACS's seventy-fifth anniversary in 1952. Though this history is not concerned with just the issue of professionalization, there is a great deal discussion about that topic in chapters about the early years of the society. In fact, the authors of the history of the ACS make an assertion similar to those contained in the history of the Franklin Institute that "problems of professional recognition or status were of little or no importance to the founders of the Society. Judged by present standards virtually all were concerned with chemistry largely from an academic point of view.... Gradually that began to change."⁷⁵ In somewhat of a contrast to this view of the

⁷⁴ Bruce Sinclair, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824-1865*. (Baltimore, MD: Johns Hopkins University Press, 1974), 82-84.

⁷⁵ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 205.

chemistry profession, there is another work more focused on the professionalization of chemistry written twelve years later. Edward Beardsley criticizes Browne and Meek's work which he suggests "romanticized the work of society building,"⁷⁶ and contextualizes chemistry more broadly saying that the profession derives from "the premise that science derives many of its goals, its institutional support, and its support from the larger society of which it is a part."⁷⁷ Though very different from the work of historians not trained in chemistry, these histories provide a useful narrative of the overall development of the chemistry profession.

History of Universities

Scientific associations are also closely linked with the institutions that often employ these professional scientists. Andrew Abbott, in addition to stressing the importance of professional organizations also discussed how linked ecologies developed between universities and professional associations.⁷⁸ Therefore, one cannot understand the social institutions of science without understanding how universities interact with professional associations. The research on the history of higher education is immense, however. Therefore, for the purposes of this dissertation, it is important to narrow down this large body of work to a subset most relevant to this study. Since this literature review is specifically interested in bringing together historical perspectives on scholarly communication, particularly in the nineteenth-century U.S., the large number of studies on the history of American universities has been narrowed only to research that is interested primarily in the relationship between professional associations and universities. This sampling of literature on higher education discusses the issues of authority and trust, and

⁷⁶Edward H. Beardsley, *The Rise of the American Chemistry Profession, 1850-1900*. (Gainesville, FL: University of Florida Press, 1964): 75.

⁷⁷ *Ibid*, ii.

⁷⁸ Andrew Abbott, "Linked ecologies: States and universities as environments for professions," 245-274.

how such social constructs are derived. These works on the history of universities also examine how universities have both benefited from and contributed to the creation of specialized disciplines within science.

In the nineteenth century, universities were developing in tandem with professional associations. Additionally, as genres of writing were developing within journals, many of which were controlled by these professional associations, universities were contributing to the legitimation of certain forms of writing. Eventually such practices of writing in professional journals and contributing to the research of specialized academic disciplines became formalized in a tenure and promotion system, that, as Marcel LaFollette has suggested, likely became institutionalized sometime after 1940.⁷⁹

Universities and the Nature of Authority

One of the major differences between the United States and Europe lay in their respective higher education systems. In the late eighteenth century when Wilhelm von Humboldt wrote his *Theory of Human Education* that led to the reform of German Universities and public education, universities became instruments of the state, and William Clark has suggested that, unlike their American counterparts, German professors were employees of the state and subject to the bureaucratic controls that the state could provide.⁸⁰ In the United States, however, colleges and universities were run by a variety of different entities in the early nineteenth century, some religious, some secular, and some even quasi-state run. By the 1860s, however, because of public education reform in the United States and legislation such as the Morrill Land Grant Act,

⁷⁹ Marcel LaFollette, "Crafting a communications infrastructure," 259.

⁸⁰ William Clark. *Academic Charisma and the Origins of the Research University*. (Chicago: University of Chicago Press, 2006), 464-466.

higher education in the United States acquired an element of state-run bureaucracy similar to that in Germany on which the United States partially modeled its own system of both public schools and higher education.⁸¹

Fundamentally there is one important difference between these two systems (American and German); certain entities (state, religious, or others) controlled access to and application of knowledge in different ways; Germany tended to emphasize theory and the United States usually favored industrial application.⁸² Some scholars within the history of education have suggested that all science (regardless of country) is primarily about control either of knowledge or of its application.⁸³ The developments in education and scientific philosophy within the United States have led historians of science such as Steven Shapin to remark that, “What the state wanted, and what it increasingly could secure from scientifically trained practitioners was not natural philosophy but instrumental expertise, not knowledge, but knowledge-power, not Truth but competence in predicting and controlling.” Thus, according to Shapin, “the links between the state, commerce, and natural knowledge had crucial bearings on appreciations of the identity of both the man of science and scientific knowledge.”⁸⁴ Similarly, Robert Kargon and Scott Knowles, writing about the development of scientific education in the nineteenth century wrote that this period was critical “in the relationship between science and practice, with theoretical knowledge, especially in electro-magnetism and organic chemistry, yielding profits and products

⁸¹ Stanley Guralnick, “The American Scientist in Higher Education, 1820-1910.” In *The Sciences in American Context: New Perspectives*, ed. Nathan Reingold (Washington, D.C.: Smithsonian Institution Press, 1979), 114-119.

⁸² Mitchell G. Ash, “Bachelor of What, Master of Whom? The Humboldt Myth and Historical Transformations of Higher Education in German-Speaking Europe and the US,” *European Journal of Education*, 41 (2006): 251-252.

⁸³ Richard Whitley. *The Intellectual and Social Organization of the Sciences*. (Oxford: Clarendon Press, 1984), 14-15.

⁸⁴ Steven Shapin, *The Scientific Life: A Moral History of a Late Modern*, 39-40.

through new manufacturing techniques and organized industrial research.”⁸⁵ A key difference between Germany and the United States was first and foremost an emphasis in the United States on usefulness and, a key to such usefulness was service to industry.

In the early nineteenth century there was a proliferation of scientific schools in the United States.⁸⁶ In part, this trend was drawn from American educational leaders’ understanding of the educational system in Europe, where the study of mining at the École des Mines in Paris and the Royal School of Mines in Freiberg, Germany had risen to prominence. At the same time, there was an abundance of resources in the United States, particularly as the American West was opening for development. Therefore, it made sense for American universities to teach mineralogy and chemistry in order to provide industry with the growing demand for knowledge in these fields.⁸⁷ For example, the Lawrence School at Harvard University was explicitly founded with the purpose of training men “who intend to enter upon an active life as engineers or chemists, or, in general, as men of science applying their attainments to practical purposes.”⁸⁸

Ideas about industrial scientific training within universities found receptive audiences around the United States, principally in places where there was rapid industrialization.⁸⁹ At the same time, these scientific schools were rapidly changing their curricula in a practically oriented direction in order to meet the needs of economic development.⁹⁰ Additionally, as these needs of industry increased, governments both in the United States and Europe encouraged a rapid

⁸⁵ Robert H. Kargon and Scott G. Knowles. “Knowledge for Use: Science, Higher Learning, and America’s New Industrial Heartland, 1880-1915.” *Annals of Science*, 59 (2002): 1.

⁸⁶ Stanely Guralnick, “The American Scientist in Higher Education,” 104-105.

⁸⁷ Martin D Saltzman. “Benjamin Silliman Jr.’s 1874 Papers: American Contributions to Chemistry.” *Bulletin of the History of Chemistry*, 36, no. 1 (2011): 32.

⁸⁸ Robert H. Kargon and Scott G. Knowles. “Knowledge for Use,” 2.

⁸⁹ *Ibid*, 19.

⁹⁰ *Ibid*, 2-3.

penetration of market values and ideologies into the universities that they either controlled directly or through subsidies. Furthermore, many universities, especially in the United States tried to divorce scientific and objective learning from the moral and religious education that had in the early nineteenth century formed much of the basis of the curriculum.⁹¹ In all, during the nineteenth century, the expansion of industrial needs, population growth, and perceived opportunities for economic growth led to rapid changes within the field of teaching, the curricula taught, and, perhaps more importantly, to the research that university teachers were encouraged to pursue.⁹²

One of the best examples of an individual who exemplifies university reforms to meet industrial needs during the nineteenth century is Alexander Dallas Bache, who also was heavily involved in the creation and institutionalization of professional scientists (with the AAAS for instance). Bache also went to Europe and studied the educational systems of several countries including Germany, and, upon his return to the U.S., he wrote a report about reforming the American university and elementary school systems. Bache, according to Hugh Slotten, was part of a much broader “Whig culture” within the U.S. at the time, and this culture, “favored economic growth and technological development, which, he [Bache] believed, would lead to general progress and prosperity.”⁹³ Moreover, according to Slotten, Bache believed that promoting scientific and technical education over other traditional forms of education, such as study of Latin and Greek, would help America to achieve a new and superior form of moral

⁹¹ Julie A. Reuben, *The Making of the Modern University: Intellectual Transformation and the Marginalization of Morality*. (Chicago: University of Chicago Press, 1996), 268-269

⁹² William Clark, *Academic Charisma*, 464-465.

⁹³ Hugh R. Slotten, “Science, Education, and Antebellum Reform: The Case of Alexander Dallas Bache,” *History of Education Quarterly*, 31, no. 3, (1991): 329.

stature that would raise it above the status of universities in Europe.⁹⁴ Thus, at least for important figures like Bache, authority in both science and universities derived from the need for industrial progress. The beliefs of people like Bache have continued to dominate universities even to this day. Talcott Parsons and Gerald Platt in their sociological work on universities have concluded that “the integration of professional training in the university is an empirical feature of the American system of higher education.” Furthermore, “postindustrial society has become as never before, dependent on *theoretical* knowledge and the university has become the locus of its development.”⁹⁵ Thus, this tight integration between scientific knowledge and industrial progress was, for Parsons and Platt, an essential component of higher education, much as people like Bache envisioned.

Janice Radway agrees with many of these assertions about the changing nature of higher education during the nineteenth century, “These developments altered the American college irrevocably, their emergence was bound up most intimately with the appearance of the American research university in the years between 1870 and 1915.”⁹⁶ Radway goes further, however, to connect these changes to the print culture of late nineteenth-century America and, more importantly to the publishing practices of professional scholars during this period. In ways similar to Burton Bledstein’s arguments about professionalization and middle-class life, Radway argues that the increasing number universities also had a rising need to rely on publication in scientific journals (including but not necessarily limited to journals tied to associations such as the American Chemical Society). At the same time, these new scientific professionals who

⁹⁴ *Ibid*, 335.

⁹⁵ Talcott Parsons, and George M. Platt, *The American University*. (Cambridge, MA: Harvard University Press, 1975): 226-227.

⁹⁶ Janice Radway, “Research universities, periodical publication, and the circulation of professional expertise: On the significance of middlebrow authority.” *Critical Inquiry*, 31, no. 1, (2004): 204.

worked in universities tried to differentiate their occupations and forms of writing as separate from that of literary and other humanistic writers that were often published in popular literary journals at the time.⁹⁷ In some ways, Radway's arguments mirror some of the observations made by Andrew Abbott who also suggested that "pure" research can often be identified by its inaccessibility to a general audience.⁹⁸ Thus, Radway ties this new industrial culture within universities in the U.S. to a broader print culture that is also causing practitioners within universities to publish in new ways within newly established scientific periodicals during the late nineteenth century.

Other scholars have examined different sources of authority within higher education. Roger Geiger has suggested that universities during the late nineteenth century achieved much of their authority from the alumni who supported them philanthropically. The universities that had alumni within more lucrative industries were able to achieve a prominence that other universities were unable to match including the Universities of Pennsylvania and later Michigan in fields such as chemistry and mineralogy (both lucrative professions in the nineteenth century). Furthermore, according to Geiger, many universities achieved only regional status within a range of one hundred miles, because populations during this part of the century were largely less mobile.⁹⁹ James Axtell has argued that original research became a hallmark of university authority, especially the university's ability to publish and disseminate original research. For instance, Johns Hopkins University took a lead in creating a "publication agency" to publish

⁹⁷ *Ibid*, 228.

⁹⁸ Andrew Abbott, *Chaos of Disciplines*, 145.

⁹⁹ Geiger, Roger L., ed. *The American College in the Nineteenth Century*. (Nashville, TN: Vanderbilt University Press, 2000): 32-35.

early journals such as the *American Journal of Mathematics* (1878) and the *Johns Hopkins University Studies in Historical and Political Science* (1882).¹⁰⁰

Universities and the Creation of Disciplines

Authority within universities was, however, created in ways in other than through ties with industry. The creation of disciplines and their bureaucratization within universities is another important aspect of establishing authority, at least within the United States context. Another part of Humboldt's German reform was the creation of a research ideal within the university, or a belief that faculty should be rewarded less for teaching and more for performing original scholarly investigations. Often this is the part of the history of higher education that gets most emphasized. Yet, the development of the "research ideal" within the United States higher education system is especially complicated. On the one hand, universities had a teaching mission and derived their authority from the industrial needs they purported to serve. On the other hand, the professionals teaching courses were often more interested in creating a professional identity, which, as Andrew Abbott has noted, often involved creating "pure" and less practical research. In a 1979 volume edited by Nathan Reingold, Stanley Guralnick frames the conflicts between these different groups of scientists (teaching-oriented faculty and professional research scientists) in terms of curricular developments. Prior to 1875, Guralnick argues, there was little emphasis on research in higher education, and faculty members were typically "practitioners." After 1875, however, because of the research reforms of higher education in the United States and an increasing number of scientific schools that also demanded narrower curricula, the kinds of scientists employed by universities were increasingly involved in

¹⁰⁰ James Axtell, *Wisdom's Workshop: The Rise of the Modern University*. (Princeton, N.J.: Princeton University Press, 2016): 273.

producing research rather than teaching.¹⁰¹ Guralnick also emphasizes, however, that these two missions of teaching and research should be seen as complementary, not competing.¹⁰² In all, according to Guralnick, American universities were uniquely suited to rapid changes during the later nineteenth century.

Anja Werner, in a book discussing the migration of American scholars to Germany during the late nineteenth century, this period of rapid change, suggests similar tensions as Reingold and Guralnick. Yet she also discusses how these tensions came into being. Unlike the U.S., Germany had more extensive networks of scientists working within discipline-like structures; moreover, Germany had an inflexible and standard set of academic departments. Unlike Germany, American universities in the nineteenth century had a more flexible system of academic departments. American students who studied in Germany were able to create networks among other Americans in order to study new problems, and, once they had finished their education, these students often set up new departments around newly forming disciplines within American universities. Psychology for instance was but one example of this form of disciplinary invention. There were many practitioners studying psychology and working in scattered departments in Germany, but the United States offered the ability to bring diverse networks together and to establish them more formally within university departments.¹⁰³ At the same time, these networks of German-trained Americans were quite different than the networks being created by industrial professional associations (those working in the field), though of course

¹⁰¹ Stanley Guralnick, "The American Scientist in Higher Education, 1820-1910," in *The Sciences in the American Context*, edited by Nathan Reingold. (Washington, D.C.: Smithsonian Institution Press, 1979), 99-103.

¹⁰² Stanley M. Guralnick, *Science and the Ante-Bellum American College*. (Philadelphia: The American Philosophical Society, 1975): 159.

¹⁰³ Anja Werner, *The Transatlantic World of Higher Education: Americans at German Universities, 1776-1914*. (New York: Berghahn, 2013): 231-232.

there was some overlap between these two groups. Over time, a greater divide emerged between the networks of students who desired training to work in industry and their teachers who were networking among fellow American and German researchers.¹⁰⁴

This discrepancy between the American university's commitment to serving industrial needs while, at the same time, focusing on its own professional needs has led scholars like Chad Wellmon to trace the development of this divide over the course of the late nineteenth century. Despite the great advantages of these networks of scholars, and the abilities of Americans to create new disciplinary structures, there was an incongruity between the new structures German-trained American scholars were attempting to create in the U.S. and the model of departments and faculties at German universities from which these Americans were importing their ideas. William Clark suggests that German universities were ultimately instruments of the state and as such created bureaucratic structures that attempted to extend state power over the faculty members within those universities. In fact, the Ph.D. degree was created as a method for German academics to achieve credentials for supporting state functions.¹⁰⁵ Wellmon, drawing on the work of Max Weber, has suggested that in American research universities, "the logic of specialization was ineluctable, and . . . the institution designed to embody science as a way of life had become just another modern, rationalized bureaucracy."¹⁰⁶ Over time, the bureaucracies that academics created within their universities and the bureaucracies that the state imposed to support education caused universities as institutions to be in a perpetual state of conflict within themselves.

¹⁰⁴ *Ibid*, 265-266.

¹⁰⁵ Chad Wellmon, *Organizing Enlightenment: Information Overload and the Invention of the Modern Research University*. (Baltimore, MD: Johns Hopkins University Press, 2015): 230-231..

¹⁰⁶ *Ibid*, 259.

In *Undisciplining Knowledge*, Harvey Graff provides two historical examples of the sort of conflict identified by Wellmon. Graff traces the history of sociology and biology during the period of 1890 to 1920. Sociology and biology were originally conceived as *the* disciplines to study, respectively society and life. Yet, the needs of industry required that sub-specialties be developed within each of these disciplines to meet the needs of criminology, economics, political science, and social work in the case of sociology, and medicine, public health, veterinary science, agriculture or genetics in the case of biology. While the overall separation among disciplines and sub-disciplines occurred (beyond just sociology and biology), disciplines vied to be the preeminent field of study that could explain other areas of research (for instance sociology can explain history and other social sciences, or physics can explain chemistry and other physical sciences). The way these disciplines attempted to gain their preeminence was by garnering support from industry and from the state, and thus creating bureaucracy that put each of these sub-disciplines into conflict with each other, even in cases where these sub-disciplines may have been studying very similar topics.¹⁰⁷

History of Scientific Journals

In ways similar to those who have written about the history of professionalization and higher education, scholars researching the history of journals also come from multiple disciplines and perspectives. Primarily, the fields that investigate the history of journals include the history of science, history of the book, communications, and information studies. Scholars from all of these fields would probably agree that the research article is one important artifact that is produced from the larger social trends of professionalization and bureaucratization of

¹⁰⁷ Harvey J. Graff, *Undisciplining Knowledge: Interdisciplinarity in the Twentieth Century*. (Baltimore: Johns Hopkins University Press, 2015), 49-51.

universities. Research articles became a genre of writing unique to professional scientists. Despite the prominence of the research article in so many different fields of scientific research, few scholars have investigated the specific origins of this important genre of writing, though nearly all of the literature alludes to the development of modern scholarship outputs within a much longer evolution of academic journals.

Within the body of scholarship about the history of journals, there has been much more written about the early history of academic journals in the seventeenth and eighteenth century than there has been about the development of research articles in the nineteenth century. Scholars have been chiefly interested in understanding the history of organizations such as the Royal Society, and its associated journals such as the *Philosophical Transactions of the Royal Society*. Generally, there has been less interest in journals begun at the time that American professional organizations such as the AAAS or the ACS were founded. What interest there has been in the nineteenth-century period has two major constraints. First, this body of research has largely been confined geographically to Europe, particularly Britain and Germany. Additionally, this research has been written primarily by historians of science, thus limiting much of the application of the research to that field.

There is one research area that has cut across all of these historical periods, however: communication studies. More than any other research area, scholars studying rhetoric and composition have tended to cut across time and to write broad studies that span the course of hundreds of years. These studies, though valuable, have had one significant weakness, a tendency to use a relatively small set of articles as evidence to prove much broader points about the history of communication. For instance, Gross, Harmon, and Reidy sample 100 passages from the *Philosophical Transactions* for their discussion of the seventeenth century and 188

passages from 37 English language journals for their discussion of the nineteenth century. Additionally, scholars in communication studies have tended to focus on the twentieth century and attempted to find the origins of modern composition in scientific articles in much earlier time periods.

This review will focus on just two time periods: the early history of scientific journals in the seventeenth and eighteenth centuries and the nineteenth century. These two periods in the development of the scientific journal can help to show two characteristics of early scholarly journals. First, it is possible to see how the developments in scientific writing shaped the most important aspect of histories of the journal. Second, one can trace the evolution of what started as brief reports of scientific experiments in early journals to more well-developed mechanisms for producing research articles such as what might be found in modern scientific journals. Overall, the development of research articles began long before such outputs became a modern standard for tenure and promotion.

Early History of Journals: Seventeenth and Eighteenth Centuries

It is important to note before even discussing journals such as the *Philosophical Transactions of the Royal Society*, that there had already been a long tradition of sharing research among scientists. Correspondence networks were an important part of early modern scientific communication, and, to a large degree, early journals relied on these pre-existing correspondence networks that persisted alongside journals throughout the eighteenth century.¹⁰⁸ David Kronick has argued that letters between scientists and other natural philosophers had specific influential members who served as informal regulators of correspondence between members of these

¹⁰⁸ "Mapping the Republic of Letters," Homepage, last modified 2013, <http://republicofletters.stanford.edu/>.

networks. Additionally, these organizations of correspondence provided for the institutionalization of many of the royal academies that developed in the seventeenth and eighteenth centuries.¹⁰⁹ A prime example of an informal network that evolved into a formalized journal would be the correspondence network of Henry Oldenburg, later the editor of the *Philosophical Transactions of the Royal Society*. Oldenburg had a wide correspondence network and forwarded many of his letters to others who he thought might be performing similar experiments. Early issues of the journal often contained printed versions of letters Oldenburg received and which he believed would be of interest to other members of the Royal Society.

The informal networks of scientists working independently of formalized institutional structures has often been referred to as the “invisible college.” This invisible college of science is particularly interesting because, as Manuel Castells has argued, it transcended boundaries of both “spaces of place” and “spaces of flows.”¹¹⁰ In other words, the scientific network was not bound by geographical constraints (spaces of place), nor was it bound by already existing trading routes (spaces of flows). Nonetheless, the correspondence network of scientists did create its own system of hubs and spokes based upon either certain individuals or geographical areas where scientists specialized in specific areas of study. Therefore, the republic of letters was in many ways a precursor to what would become instantiated in the journals that would later print these letters of correspondence along with other genres of documenting research during the eighteenth and even into the nineteenth century.¹¹¹ In fact, in the case of the *Philosophical*

¹⁰⁹ David A. Kronick, “The commerce of letters: Networks and ‘Invisible Colleges’ in seventeenth- and eighteenth-century Europe.” *Library Quarterly*, 71, No. 1 (2001), 28 – 43.

¹¹⁰ Manuel Castells, *The Rise of the Network Society*. (Chichester: Wiley, 2010), 440-459.

¹¹¹ Janet Browne, “Corresponding naturalists.” In *The Age of Scientific Naturalism: Tyndall and His Contemporaries*, edited by Bernard Lightman and Michael S. Reidy, 157–69. London: Pickering & Chatto, 2014.

Transactions of the Royal Society, Henry Oldenburg played a major role in exploiting his correspondence network in order to create the journal for the Royal Society of London.¹¹²

In part because of the already existing scholarship on correspondence networks, the body of literature within history of journals in the seventeenth and eighteenth-centuries is probably the best developed and most diverse, including a wide variety of different studies from different disciplines. In the field of information studies, David Kronick has done extensive quantitative analysis on the types of scientific periodicals that were produced between 1665 and 1790. Like Peter Burke, Kronick suggests that scientific publications were tied more closely to journalistic expectations of science, at least during this early period.¹¹³ Communications theorists have also analyzed the research article using more quantitative methods and have come to the conclusion that rhetorical styles evolved significantly over time.

The focus of communications scholars has been much wider than that of most historians, and communication scholars such as Alan Gross, Joseph Harmon, and Michael Reidy have argued that argumentative styles and the construction of fact are the two dimensions that have changed the most significantly between the initial formation of journals like the *Philosophical Transactions* and the scholarly media that exist currently.¹¹⁴ In all of these studies, scholars agree that there were two important factors that helped to create the phenomenon of the research article: authority and sociability. Authority has many different sources, and sociability, or the

¹¹² Robert Iliffe, "Making correspondents network: Henry Oldenburg, philosophical commerce, and Italian science, 1660–72." In *The Accademia del Cimento and Its European Context*, edited by Marco Beretta, Antonio Clericuzio, and Lawrence M. Principe, 211–28, Sagamore Beach, MA: Science History Publications, 2009.

¹¹³ David A. Kronick, *A History of Scientific and Technical Periodicals: The Origins and Development of the Scientific Press, 1665-1790*. (Metuchen, NJ: Scarecrow Press, 1976).

¹¹⁴ Alan G. Gross., Joseph E. Harmon, and Michael Reidy. *Communicating Science: The Scientific Article from the 17th Century to the Present*. (Oxford: Oxford University Press, 2002).

social realities of who was reading and who was writing these research articles, also contributed to the construction of authority.

Most of the research on the seventeenth and eighteenth centuries has focused on the social forces shaping the academies and societies, such as the Royal Society of London, that were developing during that time period. Like much of the history of journals in the nineteenth century, much of this research is concerned with the development of a social system of peer review. Additionally, many of these studies of journals in the seventeenth and eighteenth centuries have focused on the editors of particular journals and their assistants. For instance, one example of a common focus of study is the founding editor of the *Philosophical Transactions*, Henry Oldenburg (1619-1677), who is often credited as the inventor of peer review. One reason many scholars focus on Oldenburg is because, officially, the *Philosophical Transactions*, at least in the early period, was not a publication from the Royal Society; it was a project of Oldenburg himself. Nonetheless, most contributors and readers of the periodical viewed the journal as a sanctioned publication of the society.¹¹⁵ In fact, Oldenburg's influence gave the *Philosophical Transactions* an authority that other journals did not have. For instance, many of the communications of the Académie des Sciences, were the product of a very loose confederation of authors and disciplinary clusters making it difficult to see which individuals or groups were actually behind particular categories of research.¹¹⁶ Oldenburg on the other hand possessed a large network of correspondents, some of whom were named specifically and some of whom were not. Because of this network, Oldenburg was able to create a "textual representation of the

¹¹⁵ Adrian Johns, "Miscellaneous Methods: Authors, Societies, and Journals in Early Modern England," *The British Journal for the History of Science*, 33 (2000): 166.

¹¹⁶ Mario Biagioli, "From Book Censorship to Academic Peer Review," *Emergences*, 12 (2002): 23.

scientific debate – an instrument for the construction of a ‘collective intelligence’” which was unique in Europe.¹¹⁷

Robert Iliffe has identified another form of authority for editors like Oldenburg during the early modern period, including within journals like the *Philosophical Transactions*. During this period there was an explosion of information of various types, and even within England, there were several periodicals, such as the *Mercury*, that purported to provide scientific information. Even though journals like the *Mercury* did not carry the imprimatur of the Royal Society, they did report on scientific news and from the point of view of many readers might have been seen as a legitimate source of news about scientific matters. Also, within the periodical press, there were many attacks both on the character of individuals and on the ideas they presented. Iliffe suggests that, “in the Royal Society, whoever could successfully manage his name and identity was king, as was whoever controlled the public credibility of his targets.”¹¹⁸ In the case of the *Philosophical Transactions*, Oldenburg controlled both the identity of authors and, if necessary, the credibility of those with whom the author might disagree (the “targets”). Therefore, editors like Oldenburg provided an essential service as a facilitator between the reader and the author.

Overall, editors like Oldenburg provided a source of authority on multiple levels, including within the *Philosophical Transactions*. On the one hand, such editors were a source of authority that could mobilize a network of scientists and provide a newsletter for scientific issues throughout Europe. However, later editors saw themselves as advocates for promoting

¹¹⁷ Ellen Valle, “Reporting the Doings of the Curious: Authors and Editors in the *Philosophical Transactions* of the Royal Society of London,” in *News Discourse in Early Modern Britain: Selected Papers of CHINED 2004*, edited by Nicholas Brownlee (Bern, Switzerland: AG International Academic Publishers, 2006), 88-89.

¹¹⁸ Robert Iliffe, “Author-mongering: The ‘Editor’ Between Producer and Consumer” in *The Consumption of Culture, 1600-1800: Image, Object, Text*, edited by Ann Bermingham and John Brewer, (London: Routledge, 1995), 178.

individual methods or scientific experiments within the Royal Society. Noah Moxham has stated in his history of the *Philosophical Transactions* that, “Oldenburg’s periodical had put the Society at the centre of a network of scientific communication; Grew’s and Hooke’s respective publications had the capacity to demonstrate its productivity in matters of research.”¹¹⁹ Both of these views of editorial authority, however, rest on an assumption that these editors are getting their content from the source of some type of individual author. The authority of those authors, in turn, helps the editors to maintain their influence both over the journal and within the broader research communities of which the editors were a part.

Individual authorship within the *Philosophical Transactions* is somewhat difficult to trace. In particular, during Oldenburg’s editorship, his voice was quite strong and often tended to overshadow individuals writing to him.¹²⁰ Scholars have had different views about the role of this early period of the academic journals with David Kronick for instance suggesting “authority and credibility in science, nevertheless derived ultimately from the author or originator of the work.”¹²¹ Mario Biagioli on the other hand has argued for a more collective authorship in which individual voices were downplayed.¹²² Ellen Valle, however, suggests that the seventeenth and early eighteenth centuries are a transitional period in which the editor’s role shifts with, “the relationship observable in the texts between the editorial and the authorial voice, and the gradual emergence and strengthening of the latter at the expense of the former.”¹²³ In a way, individual authorial credibility during the early period of academic journals derives from hybrid sources.

¹¹⁹ Noah Moxham, “Fit for Print: Developing an Institutional Model of Scientific Periodical Publishing in England, 1665-CA. 1714,” *Notes and Records of the Royal Society*, 69 (2015): 250.

¹²⁰ Ellen Valle, “Reporting the Doings of the Curious,” 75.

¹²¹ David Kronick, “Authorship and Authority in the Scientific Periodicals of the Seventeenth and Eighteenth Century,” 257.

¹²² Mario Biagioli, “Etiquette, Interdependence, and Sociability,” 220.

¹²³ Ellen Valle, “Reporting the Doings of the Curious,” 73.

On the one hand, individuals have some credibility. On the other hand, their credibility rests with an editor's ability to validate results and to channel the patronage and authority conveyed by the editor's authorizing institution or journal. In other words, though the editor's role may diminish in terms of what a reader can visibly see in the periodical (in terms of whose name is attached to an individual piece of writing), the editor still conveys greater authority to individual authors.

David Kronick has also suggested that individual authors during this period were not the source of authority themselves but rather, "an 'expert witness.' In other words an author's credibility and authority are established through a system of social and intellectual controls which apparently have not yet been adequately analyzed or described."¹²⁴ In the thirty years since Kronick's book was published, however, Biagioli and other scholars have described the development of these social controls. Biagioli argues that the social norms of authors and editors are a product of patronage and the authority of the governing body, "The recognition of individual authorship . . . effectively allowed the academicians to articulate institutional protocols so that they could legitimize their work through their own interdependence rather than through their dependence on the prince."¹²⁵ Ellen Valle takes a more practical view and sees the editor's role not as a form of legitimation but rather as a way of regulating the flow of information.¹²⁶ Overall, however, all of these scholars recognize that individual authors have a certain amount of credibility, and that reliability is enhanced by the editor, the editor's network, and, most importantly the institution that the editor represents.

¹²⁴ David Kronick, "Authorship and Authority in the Scientific Periodicals," 256.

¹²⁵ Mario Biagioli, "Etiquette, Interdependence, and Sociability," 226.

¹²⁶ David Kronick, "Authorship and Authority in the Scientific Periodicals," 270.

Scholars have also identified a second source of authority beyond authors and readers. Institutional authority is perhaps the most important of these types of authority and in fact combines the separate authorities of the government, editor, and author. Most importantly, however, institutional authority rests on the ability of multiple witnesses to read and verify the researches of individual authors. David Kronick compares the power of institutions like the Royal Society to a court of law where the authority of an individual is tied to the credentials that an individual institution conveys upon it. To prove his point Kronick discusses two particularly relevant examples. First, the Académie des Sciences had particular regulations about what needed to be witnessed in order to be printed in their journals, and apparently the Académie de Chirurgie went even further in their regulations which forbade individuals from using the name of the society without similar witnessing “on pain of exclusion from the society.”¹²⁷ Biagioli agrees in part with the arguments that Kronick makes, but suggests that the authority of institutions is not necessarily in the credentials that they convey and the regulations they make in order to enforce those credentials, but rather the network that they provide which legitimizes the work of individual authors.¹²⁸

All of these social factors arguably affect the very ways in which articles are written, or how genre is created during the seventeenth and eighteenth centuries within these early academic journals. *Philosophical Transactions* contains several different genres of writing. These genres are fairly mercurial and can often appear somewhat differently even within a single issue. Nonetheless, there are three categories that appear consistently during the late seventeenth and early eighteenth century: book reviews, correspondence reports, and registers. Two of these

¹²⁷ *Ibid*, 257-263.

¹²⁸ Mario Biagioli, “Etiquette, Interdependence, and Sociability,” 210.

categories, book reviews and correspondence reports, are dominated by an editorial voice, and in many cases were actually written by the editor himself. The third, registration, or the publication of experiments that had been observed and witnessed in front of members of the Royal Society, was still heavily influenced by the editor, but at the same time takes on the voice of individual authors. Over time, a new genre began to emerge, an idea of reports on original research which now of course is common and expected within academic journals, but during this period was still not fully developed. This nascent concept of a “research article” became a tool that Lorraine Daston described as a repository of data that scientific practitioners could use to test their own theories, or a tool “for discovering invisible patterns and regularities as a first step to building theories.”¹²⁹ Furthermore, Daston has suggested that this tool eventually became and is now considered the cornerstone of research communication, but in the seventeenth century that concept evolved quite significantly.

Thus, knowledge claims, “research articles”, or perhaps more appropriately stated knowledge claims about experiments, came to be registered publicly through the *Philosophical Transactions* rather than just the Royal Society’s public register. The official move to institutionalize a procedure of registering knowledge claims did not happen until 1752 when the Royal Society officially acknowledged the journal as its publication and assured that there were editors who could maintain continuity over time. Noah Moxham identifies “two strands of Royal Society publishing, both of them more closely tied to the institution than any that had previously existed: one formally linked to a renewed programme of experimentation and the other taking advantage of a repository of material languishing unpublished in the Society’s

¹²⁹ Lorraine Daston, “Super-Vision: Weather Watching and Table Reading in the Early Modern Royal Society and Académie Royale des Sciences,” *Huntington Library Quarterly*, 78 (2015): 214-215.

archives.”¹³⁰ Thus a new idea of what should be included in a journal emerged. In the eighteenth century the journal of a scientific society, at least that of the Royal Society, was not simply a method for creating news about scientific issues throughout Europe; nor was the journal a mechanism for extending such news by reviewing books that related to the journal’s content. Furthermore, the journal was not about maintaining a correspondence of scientists throughout Europe, as Oldenburg had done. Rather, the *Philosophical Transactions* became a way of registering knowledge.

It is important to point out that the individual articles within the journal were still not “research articles” in the modern sense, even in the midst of this evolution. Articles were not peer-reviewed, “the Society did and did not peer-review the journal: it reviewed each issue of the *Transactions* as a book, but did not select each article through peer review.”¹³¹ There was also still some doubt as to what the journal should contain. Edmond Halley in 1714 stated that the function of the periodical should only be about preservation of tracts too short for a book, publication of letters, and printing of experiments performed at society meetings, despite the fact that the journal had long been doing things very different from this.¹³² Furthermore, the Royal Society itself long debated whether *Philosophical Transactions* was the appropriate venue to register knowledge claims. At times the society appeared to think that the journal should only be for foreign correspondents. At other times it felt that the journal should only be for knowledge that the society itself could register and exploit.¹³³

¹³⁰ Noah Moxham, “Fit for Print,” 248.

¹³¹ Mario Biagoli, “From Book Censorship to Academic Peer Review,” 30.

¹³² Noah Moxham, “Fit for Print,” 253.

¹³³ *Ibid*, 255.

Nonetheless, despite these multiple views of what the *Philosophical Transactions* should be, there is one indisputable fact. By 1752 it was no longer the same type of publication that it had been in 1665 when it started. By 1752 the journal was now publishing and registering knowledge claims both by its own members and by correspondents outside of the society. These knowledge claims took a new form that was very different from simply edited reports of what others were doing. Individual authors became more prominent, and the essential elements of what would eventually constitute the “research article” took shape from a combination of genres, social practices, and authorities. All of these forces combined to evolve into a new form of knowledge claim for which the *Philosophical Transactions* became a primary provider throughout Europe. It was, however, a mechanism that had a unique combination of important characteristics that helped it to become both the hub of a network and a forum to present knowledge claims that may in turn have influenced the development of research elsewhere.¹³⁴

Later History of Journals: The Nineteenth Century

The evolution of the research article continued even beyond the eighteenth century. Communications scholars such as Alan G. Gross, Joseph E. Harmon, and Michael Reidy in addition to studying the rhetoric of scientific writing during the seventeenth and eighteenth centuries have also extended their studies into the nineteenth century. Within this later time-period, these researchers have noticed two particularly important changes in scientific writing. First, scientific articles in the nineteenth century became more interested in establishing the concept of “fact” or what science could do to establish laws, principles, and methods that constitute something being definitively known. Prior to the nineteenth century, science was

¹³⁴ Aileen Fyfe, “Journals, Learned Societies and Money: *Philosophical Transactions*, CA. 1750-1900,” *Notes and Records of the Royal Society*, 69 (2015): 278.

interested more in philosophical speculations that tried to relate scientific observations to religious or social theories about the nature of the world. In the nineteenth century such practices changed, and scientists were not interested as much in proving philosophical precepts but were interested in establishing ideas that could be determined as definitively true. In part these changes were a result of professionalization; as more and more disciplines established authority over certain areas of knowledge, the focus of research narrowed to more definitively provable questions. In part this interest in fact was because of overall changes in the philosophical principles of science which during the nineteenth century changed from a method of study that tried to link scientific phenomena to theological principles toward a more empirically based methodology.¹³⁵ Furthermore, the method for establishing these facts became the process of experimentation and quantitatively measuring observed phenomena in nature.

Secondly, and somewhat ironically considering the first move away from philosophical speculations, the field shifts from what was initially a science of description into a field of theory in part because the phenomena being described were often quite complex. Therefore, the sciences were interested in determining causes of phenomena. These causes were, however, different from the methods for establishing causes utilized by scientists in previous centuries. The causes scientists strove to understand were determined by observable facts, not by *a-priori* philosophical suppositions. For physics and chemistry specifically, “the move is steadily in the direction of turning qualitative into quantitative facts and in creating a permanent reciprocity between experiment and theory.”¹³⁶

¹³⁵ David Cahan, “Institutions and Communities” In *From Natural Philosophy to the Science: Writing the History of Nineteenth-Century Science*, edited by David Cahan, 291-328. (Chicago: University of Chicago Press, 2003), 291.

¹³⁶ Alan G. Gross, Joseph E., Harmon, and Michael Reidy. *Communicating Science*, 159-160.

Rom Harré, a philosopher of science and social theorist has tied some of the themes identified by Gross, Harmon, and Reidy into his more generalized theories about social affordances within science. By drawing both Wittgenstein's theories on hinge-practices (a supposition that precedes from a certainty) and mereology (a relation between the whole and the parts) Harré argues that scientists were able to theorize more effectively when they limited themselves to only parts of a whole. By doing so they were able to create more effective models through inferences about a rather limited set of observations. According to Harré "The evidence for these inferences comes from the *affordances* which are disciplined with respect to realist or heuristic interpretations by attention to *hinge-practice and hinge-proposition pairs* which incorporate the working metaphysics of an era."¹³⁷ According to Harré modern philosophy of science is an extension of some of the earlier trends identified by Gross, Harmon, and Reidy. Less philosophical studies like those of Charles Bazerman, have focused on rhetoric and have been particularly interested in the historical development of scientific arguments within journals.¹³⁸

Like the studies of Gross Harmon, Reidy and also of Harré that have discussed some general trend in the evolution of scientific research articles during the nineteenth century, much of the work focusing on the historical contexts of journals and their role in the construction of scientific fact has also focused on journals in Britain and Europe. The situation in Europe was quite different from the United States. Generalist societies like the Royal Society of London had formed in the seventeenth and eighteenth centuries, and, as a result, when research questions began to become more specialized, new more focused academies on subjects such as astronomy

¹³⁷ Rom Harré, "New Tools for the Philosophy of Chemistry," 89.

¹³⁸ Charles Bazerman, *Shaping Written Knowledge: The Genre and Activity of the Experimental Article in Science*, (Madison, WI: University of Wisconsin Press, 1988).

or botany formed; these organizations were often also supported by the government, particularly in Britain and Germany. Like the Royal Society these specialized academies produced journals. In contrast, within the United States, there was no government-sponsored general science society. Therefore, these more specialized academies never formed. It was not until the formation of professional associations in the late nineteenth century that the manner of specialized scientific publishing common in Europe in the late eighteenth and early nineteenth centuries began in the U.S.¹³⁹

Much of the focus on nineteenth-century journals from the history of science has come from two scholars, Alex Csiszar and Melinda Baldwin. Csiszar's work is focused more broadly than Baldwin's. Csiszar has focused on scientific publishing in Britain and France during the nineteenth century, and Baldwin has focused on a case study of one particular journal, *Nature*, that started in 1869. Csiszar, like many of the scholars focusing on seventeenth- and eighteenth-century scientific publication, is particularly interested in the development of peer-review and does not focus as much on the links between professionalization and the development of universities. Melinda Baldwin's research on the other hand focuses on more than just peer-review practices, but only in relation to a single journal, *Nature*, also a British scientific journal.

Csiszar concentrates primarily on the development of scientific authority in nineteenth-century Britain. During this period, the idea of a peer-reviewed scientific journal was still very much under development, and scientists tended to publish not in the specialized journals produced by the various state-sponsored academies, but rather in newspapers of the time. According to Csiszar, there were two categories of institutional authorities that became

¹³⁹ Alan Cook, "Academic Publications before 1940," In *A Century of Science Publishing*, edited by Einar H. Fredriksson, 15-24. (Amsterdam, Netherlands: IOS Press, 2001), 18-19.

prominent in the nineteenth century that were quite different from earlier periods. The first of these were indexes. During the nineteenth century, important men of science would create indexes of the most important scientific discoveries and publish them either in newspapers or quite often as books. The second source of authority, related to the first, was the government that utilized these indexes and created its own indexes for use of government officials within the U.K. and its colonies who were tasked with scientific work. These two types of authorities combined, according to Csiszar, address “the *failure* of the authority of the collectives that had traditionally adjudicated the boundaries of scientific authority.”¹⁴⁰ Thus, it was particularly because of the failures of the state-sponsored academies to effectively create scientific authority that scientists turned to the periodical press. Because of the proliferation of scientific articles coming out of these presses, indexes became more necessary, and those indexes became the primary source of authority for scientists in Britain particularly, and to a degree in other countries of Europe.

Csiszar links these authoritative indexes into another area often discussed by other scholars interested in the history of journals: genre. In “Objectivities in Print” Csiszar makes arguments quite similar to Harmon, Reidy, and Gross, that during the nineteenth century, there was a greater interest among scientists to create a sense of objectivity in the articles that they were writing.¹⁴¹ Yet, Csiszar makes a further distinction that also reflects some of the points made by Harré. Csiszar emphasizes that scientists were responsive to particular communities, and, during the nineteenth century, “the scientific literature did not develop purely as a means of

¹⁴⁰ Alex Csiszar, “Seriality and the search for order: Scientific print and its problems in the nineteenth century,” *History of Science*, 48, no. 3/4, (2010): 426.

¹⁴¹ Alex Csiszar, “Objectivities in Print,” In *Objectivity in Science: New Perspectives from Science and Technology Studies*, edited by Flavia Padovani, Alan Richardson, and Jonathan Tsou, 145-172. (New York, NY: Springer, 2015), 145.

guaranteeing objectivity within expert communities. Rather it evolved through the relationship that these communities have cultivated with the wider polities within which they are active participants.”¹⁴² In his book on the history of the British journal in the nineteenth century, Csiszar emphasizes these points by suggesting that, “journals became not only the purveyors of scientific news but also archives of discovery, it became more common to conceive of science as a series of discrete discovery events localized in time and connected with an individual author.”¹⁴³ These expert communities of authors were becoming specialized and focused not on large generalized wholes, but rather on more focused areas of science. Overall, the genre of objective scholarly articles was part of a larger response to a scientific reading community within the U.K. and France that was interested in increasingly specialized content.

Melinda Baldwin’s work *Making Nature* serves as an excellent complement to Csiszar’s more general research on scientific periodicals in nineteenth-century Britain. Baldwin is also researching the same general time-period of the middle to late nineteenth century for the first half of her book (the second half discusses developments in the twentieth and twenty-first centuries). However, Baldwin looks only at one of these journals, *Nature*, that arguably today is one of the most significant scientific journals. Baldwin emphasizes many of Csiszar’s points about the increasing demand by audiences for scientific content. In fact, when *Nature* was founded, editors emphasized the fact that they were not a specialized journal but rather a type of periodical that was meant for anyone interested in science.¹⁴⁴

¹⁴² Alex Csiszar, “Objectivities in Print,” In *Objectivity in Science: New Perspectives from Science and Technology Studies*, edited by Flavia Padovani, Alan Richardson, and Jonathan Tsou, 145-172. (New York, NY: Springer, 2015), 165.

¹⁴³ Alex Csiszar, *The Scientific Journal: Authorship and the Politics of Knowledge in the Nineteenth Century*. (Chicago: University of Chicago Press, 2018), 8.

¹⁴⁴ Melinda Baldwin, *Making Nature: The History of a Scientific Journal*. (Chicago: University of Chicago Press, 2015), 21.

Over the course of the century, however, that dynamic changed and *Nature* became a specialized scientific journal that, unlike many other journals of the time, was able to get its issues out more quickly than others, and, as a result, to be picked up by the indexes more swiftly.¹⁴⁵ Interestingly, because of Baldwin's long scope of investigation, she makes a particular point of trying to tie *Nature's* earlier history to more modern developments, especially peer-review. Baldwin argues that, "it is tempting to view *Nature's* editorial staff as all-powerful gatekeepers of scientific success.... Since 1869, researchers have chosen *Nature* as a publication venue not because an anonymous authority decreed that *Nature* would be important but because they found that journal particularly useful." In other words, the reasons that *Nature* has been successful have differed tremendously over time, and even changed over the course of the nineteenth century.

The work on journals in the United States, at least nineteenth-century journals, is much smaller, in part, because the number of specialized scientific journals in the U.S. was also much smaller. In fact, there was only one major scientific journal published consistently throughout the nineteenth century in the U.S.: the *American Journal of Science* which began publishing in 1818 and continues into the present day. Though this journal also existed for many of the same reasons as the journals in Britain and Europe, the *American Journal of Science* also included a genre of scholarly writing that was quite different from its European counterparts during the nineteenth century: news from the field. The news found in the *American Journal of Science*, though it bears some resemblance to correspondence reports on experimental research found in British journals, was a more important feature of scientific journals in the United States during the late nineteenth century than European journals during the same time period. According to

¹⁴⁵ *Ibid*, 63-67.

Simon Baatz, the *American Journal of Science*, the primary journal for American science throughout most of the nineteenth century, was able to bring together divergent metropolitan groups in cities like New York, Philadelphia, and Boston in ways that more localized journals such as the *Transactions of the American Philosophical Society* were not.¹⁴⁶ Furthermore, the *American Journal of Science* dedicated much of its content to “announce such developments as the founding of scientific societies, changes in curricula in the colleges, reviews of new textbooks” and other news that basically inscribed the very cultural and social affordances described by Harré that were developing in the United States at the time.¹⁴⁷ This news function of journals in the United States sets it apart from its counterpart journals in Europe. Whereas Europe was quite specialized in scientific knowledge production as early as the eighteenth century, the methods and organizations for producing science in the United States were much less established until the late nineteenth century, as Reingold suggested when discussing the state of the professional field. Therefore, the most prominent journal in the United States during the nineteenth century may also have been reflecting the professional state of the scientific community at the time.

News was not the only category of material published in the *American Journal of Science*, however. Over time, it also became known as a place for quality content and scientific research articles. As Gross, Harmon, Reidy and Harré have pointed out, there was a tremendous emphasis on establishing fact. The *American Journal of Science*, perhaps because of American preferences for more practical and less theoretical science discussed by Alexandra Oleson and

¹⁴⁶ Simon Baatz, “Squinting at Silliman: Scientific periodicals in the early American republic, 1810-1833.” *Isis*, 82, no. 2 (1991): 223.

¹⁴⁷ *Ibid*, 235.

John Voss, also skewed more toward publication of practical and factual observation of science rather than generalizing theory.¹⁴⁸

The Intersections of Institutionalization, Professionalization, and Journals

In all, in addition to promoting useful knowledge through facts and quantifiable observations, scientific documents in nineteenth-century America, through journals such as the *American Journal of Science*, were ways of inscribing developments in colleges and professional societies at the time. These observations about inscriptions and professional development have long been noted by scholars of information science, especially those within the field of archival studies and diplomatics. Luciana Duranti, in discussing scientific documentation has suggested that, “the form of a document reveals and perpetuates the function it serves.”¹⁴⁹ Similarly, Fiorella Foscarini, also within the field of diplomatics, has suggested that “genres provide social codes of behavior including not only the official ‘rules of the game,’ but also any other components of ‘ceremony’ . . . surrounding the main ‘moves’ of the game – that all those involved in a dialogic exchange must learn in order to be able to ‘act together.’”¹⁵⁰ According to Foscarini, genre theory also provides a way for researchers studying particular genres to “learn how to master the genres of specific workplaces with the aim of becoming full participants in their professional communities and it includes issues of identity building, ideology, and power relations.”¹⁵¹ In other words, genres also allow researchers outside of these situated social

¹⁴⁸ Simon Baatz, “Squinting at Silliman,” 235.

¹⁴⁹ Luciana Duranti. *Diplomatics: New Uses for an Old Science*. (Lanham, MD: Scarecrow Press, 1998), 133.

¹⁵⁰ Fiorella Foscarini. “Diplomatics and Genre Theory as Complementary Approaches,” *Archival Science*, 12 (2012): 401.

¹⁵¹ *Ibid*, 403.

constructs to understand how these practitioners are using forms of writing that reflect the rules by which their professional games are played.

In the case of scientific journals and research articles in the nineteenth-century United States, the rules of the game are very similar to those that Abbott suggested, a linked information ecosystem of social affordances including universities, industry, and professional associations that perpetuate a method for industry to replicate itself through students and through practical research useful for exploitation of industry. This “linked ecology” also plays an essential role in legitimating many of the acts of inscription that are noted by Duranti and Foscarini. More importantly, this linked ecology helps to instantiate the hinge-practices and material affordances of journals that are particularly important within the scholarly communication ecosystem.

These hinge mechanisms created by cultural, social, and material affordances include specialized disciplines, journal publishing, and higher education bureaucracy, and are a part of a long narrative going perhaps as far back as the seventeenth century when organizations such as the Royal Society first emerged at the beginning of the scientific revolution. Most certainly these issues date to the late nineteenth-century in the United States. At a time when research universities were still in their infancy, when scientific journals served as a source of news in addition to research, and at a time when professional disciplinary societies were just beginning to define themselves, the scholarly communication system first began to take shape, and continues to evolve even now. There has already been extensive research on all of the aspects of scholarly communication such as the history of professionalization and universities as well as the history of journals. Yet, if one is to really understand the complete history of scholarly communication, it is necessary to understand how all three of these components of the infrastructure of scholarship interrelate.

Pre-History of American Scholarly Communication

Systems for publishing and sharing ideas existed long before formal journals or scholarly societies appeared in the United States, and many of the methods for distributing scholarship in the United States were based upon models that European academies and government-sponsored institutions created. Yet, there were some significant differences between the institutionalization of science in the United States and in Europe, specifically Britain, France, and Germany. First, there was little if any government sponsorship of scientific activities in what would become the U.S. Most scientists in the American colonies and early Republic were either members of European academies and societies or were strongly tied to the European Republic of Letters. Second, unlike many European countries, the United States was highly decentralized both geographically and politically. In Europe the central government usually controlled universities or were major sponsors of societies such as the Royal Society of London. The United States on the other hand, often relied on individual citizens to sponsor scientific pursuits with little or no government support. Finally, because there was no established system of scientific organization, there were significant struggles for power among individual scientific leaders about who should control science. This distinctive American situation led to a unique blending of scientific authority vested in societies and universities that was quite different from European models of scientific organization.

How did this American state of affairs for scientific organization evolve? From 1660 – 1746 scientists in the American colonies had no professional societies of their own and were often part of groups like the Royal Society of London (founded in 1660) or other European academies and societies. In 1746, Benjamin Franklin and fellow businessmen in the city of Philadelphia founded the American Philosophical Society, America's first learned society. By

the early nineteenth century, Philadelphia was host to several such groups including the Franklin Institute and the Academy of Natural Sciences. Boston had rival groups like the American Academy of Arts and Sciences, and New York the Lyceum of Natural History. In the 1840s, there were efforts by prominent scientists to establish national organizations and institutions. The American Association for the Advancement of Science (AAAS) became the predominant such national group. That outcome was by no means inevitable, however. In fact, the founders of what became the American Medical Association and the American Association of Geologists and Naturalists both vied for dominance in the early part of the nineteenth century, and their struggle in part contributed to the split professionally between medical practitioners and other forms of science in the United States.

Early Science in England

Historians of medieval and renaissance science have long discussed how practitioners thought about disclosing their results during the early period of science. Pamela Long has researched the notion of authorship all the way back to Greek and Roman times and has proposed several important concepts relevant to all scientific endeavors. First, she has suggested that particularly during the earlier periods of scientific discovery there was a separation and mixing of two kinds of practice, artisanal or applied knowledge and academic/esoteric work. Long also argues that there were “trading zones” in which people moved between these two spheres with relative fluidity. She goes on to suggest that in the modern age, such trading

zones are less fluid because of current requirements (university degrees, licensure, etc.) to be considered a professional.¹⁵²

William Eamon has also investigated the early history of science in Britain and tried to understand the divides between practical and esoteric knowledge. Eamon discusses the foundational figure, Francis Bacon, who is often credited as the founder of modern science. Eamon has found in Bacon's enterprise a divide similar to that articulated by Pamela Long. On the surface, Bacon and his followers condemned the kind of "esoteric" knowledge that was utilized by alchemists because they thought that it inhibited the progress of science. On the other hand, one of the reasons that Bacon believed that the arcane wisdom of the alchemists should be avoided was because he believed that there was a natural division between different kinds of knowledge, "Whereas God forbade inquiry into the precepts of morality and religion which are to be accepted on faith, he argued, inquiry into nature's secrets are not forbidden."¹⁵³ In other words, theology, philosophy, and other types of theoretical learning were outside the bounds of what "science" was. Bacon believed that science should utilize the mechanical arts, or the kinds of artisanal knowledge that Long identified rather than philosophy because "philosophical systems flourish at the hands of the first author" and "stand like statues worshipped and celebrated but not moved or advanced." Mechanical arts, Bacon believed, have "in them some breath of life [and] are continually growing and becoming more perfect."¹⁵⁴ Therefore, according to Bacon, philosophical inquiry should be left to others and scientists should devote

¹⁵² Pamela Long, *Artisan/Practitioners and the Rise of the New Sciences, 1400-1600*. (Corvallis, OR: Oregon State University Press, 2011) and Pamela Long, *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance*. (Baltimore, MD: The Johns Hopkins University Press, 2001).

¹⁵³ William Eamon, *Science and the Secrets of Nature : Books of Secrets in Medieval and Early Modern Culture*. (Princeton, NJ: Princeton University Press, 1994), 320.

¹⁵⁴ *Ibid*, 323

their own work to discovery of the “facts” of nature, a precept later institutionalized by the Royal Society of London.

Not all members of the Royal Society agreed with Bacon, however. Robert Boyle for instance feared that the Royal Society might give unwarranted access to “privileged knowledge” and alchemical secrets to people who would not be morally equipped to understand them. Additionally, John Evelyn, another of the Royal Society’s founders, was himself interested in alchemy. Though Evelyn largely supported Bacon’s ideas and also believed in the same division between mechanical and what he called “aristocratic” or esoteric arts, Evelyn suggested that there should be a hierarchical ranking of knowledge supported by the Royal Society starting at the bottom with the “Useful and purely Mechanic” (artisanal knowledge) at the bottom and ascending to “Exotick, and very rare Seacretts” (like alchemy) at the top. Evelyn later opted against working with the Royal Society on such projects, however, because he believed that publishing his results would “debase much of their esteem by prostituting them to the vulgar” and would be similar to “conversing with mechanical and capricious persons.”¹⁵⁵

There was something else underlying both Boyle’s and Evelyn’s concerns, however. Steven Shapin has argued that in the seventeenth century there was an underlying assumption that one could not practice science unless one was a “gentleman.” Being a gentleman required several overlapping requirements “a secular knightly code which laid great stress upon blood, individual honor, and reputation; a partly secular humanist culture of virtue which sought to define and defend gentry by displaying sanctioned codes of social behavior; and a highly

¹⁵⁵ *Ibid*, 331.

Christianized culture of virtue.”¹⁵⁶ Thomas Sprat in his history of the Royal Society, published shortly after the society’s foundation seems to confirm Shapin’s argument. Sprat states that, “the *Society* entertains very many men *of particular Professions* yet the farr greater Number are *Gentlemen*, free and unconfin’d.”¹⁵⁷ As a result of this underlying assumption, Eamon suggests that practically speaking, the Royal Society was restricted only to creditable gentlemen who were “worthy of the scientific calling.”¹⁵⁸

There were of course other reasons for limiting membership in the society beyond the class limitations identified by Shapin. Michael Hunter has suggested that there were practical financial reasons for including members of certain classes within the Royal Society.¹⁵⁹ Hunter has also argued that membership in the society became more widely spread among the classes over time, but there remained a certain level of education that was common to all people who attended meetings of or were affiliated with the Royal Society.¹⁶⁰ Nonetheless, regardless of whether the main criteria for including some people in the Royal Society and excluding others were for class, financial, or educational status, one additional factor was paramount. In English society at the time, there was a great divergence of views on religion (Puritan and High Church), on philosophical precepts of science, and on politics.¹⁶¹ Thus, for the Royal Society to maintain its scientific authority, it was necessary for it to find a strictly defined philosophy that would avoid very difficult political and social topics. The solution was to espouse “mechanical

¹⁵⁶ Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England*. (Chicago, IL: University of Chicago Press, 1994), 64.

¹⁵⁷ Thomas Sprat, *The History of the Royal Society of London for the Improving of Natural Knowledge*. London: Printed by T. R. for J. Martyn and J. Allestry, 1667.

¹⁵⁸ William Eamon, *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*. (Princeton, NJ: Princeton University Press, 1994), 319-320.

¹⁵⁹ Michael Hunter, *Establishing the New Science: The Experience of the Early Royal Society*. (Woodbridge: The Boydell Press, 1989), 57-58.

¹⁶⁰ *Ibid*, 79.

¹⁶¹ *Ibid*.

philosophy” which had many different definitions but was oriented toward observable and replicable truths.¹⁶²

With an emphasis on mechanical philosophical principles, elite institutions like the Royal Society often focused their work on creating practical knowledge. The *Philosophical Transactions* (the Royal Society’s journal) explicitly acknowledged its focus on mechanical arts. Henry Oldenburg, editor of the *Philosophical Transactions* wrote that, “the largeness of our Commerce abroad, and the growth of Arts at home, and the Observations of judicious Antiquaries will be a threefold advantage for the reputation and benefit of England, and cast an acceptable and obliging aspect over all his Majesties Dominions.”¹⁶³ Additionally, a great deal of scientific publishing in the sixteenth and seventeenth century focused on technical books that could be understood by the general public. Just one example of such technical writing included so-called Books of Secrets which Elizabeth Tebdeaux has discussed in *The Emergence of a Tradition*. Tebdeaux suggests that such books tended to focus on practical medicine, navigation, gardening or other practical arts utilized by non-scientists and scientists alike. Furthermore, such books “were directed more toward making the natural world predictable and explicable than exposing it as vulnerable to human manipulation.”¹⁶⁴

Most importantly, according to Tebdeaux, much of the technical publishing during the sixteenth and seventeenth centuries was dedicated to “making formerly private knowledge and behavior part of the public domain,” and “making knowledge previously reserved for academics

¹⁶² Michael Hunter, *Science and the Shape of Orthodoxy: Intellectual Change in Seventeenth Century Britain*. (Woodbridge: The Boydell Press, 1995), 14-16.

¹⁶³ Henry Oldenburg, “Epistle Dedicatory,” *Philosophical Transactions*, 9 (1674).

¹⁶⁴ Elizabeth Tebeaux, *The Emergence of a Tradition: Technical Writing in the English Renaissance, 1475 – 1640*. (Amityville, NY: Baywood Publishing Company, 1997), 157

and aristocrats available to a broad audience.¹⁶⁵ Steven Shapin has also noticed a gradual shift in truth claims over the course of the sixteenth and seventeenth centuries, Shapin suggests that the culture of the gentlemen eventually was appropriated by members of the merchant class who claimed that, “the gentry were debased and had lost their legitimate claims to deference; the mercantile classes were the genuinely honorable and truthful ones.”¹⁶⁶

Thus, in England at the end of the seventeenth century there were several methods for creation and dissemination of scientific knowledge in competition with each other. First, there was a divide between practical and esoteric knowledge which had long existed, but practical knowledge seems to be more reliably disseminated by both the Royal Society and by technical publishers. Second, there is a belief that only “gentlemen” should be practicing science. On the other hand, there is a divide between what constitutes “gentlemanly” behavior. Are gentlemen limited only to the old elite knightly class, or are merchants and the middle class also part of this group? These competing debates about how scientific knowledge should be constructed and who should be allowed to contribute to scientific debates continued in a new American colonial context as colonists created their own institutions for creation of new scientific knowledge.

American Science Before Centralization

During the seventeenth century, there were a variety of “philosophical societies” that tried to establish themselves in the American colonies. Most of them did not last very long and succumbed to unstable political circumstances and a lack of consistent government or commercial patronage. In the early eighteenth century, Philadelphia was the largest city in the

¹⁶⁵ *Ibid*, 158.

¹⁶⁶ Steven Shapin, *A Social History of Truth: Civility and Science in Seventeenth Century England*. (Chicago, IL: University of Chicago Press, 1994), 407.

American colonies and hosted the only scientific association in what would become the United States. The American Philosophical Society founded in 1746 by Benjamin Franklin aspired to be the equivalent of the Royal Society of London in the Americas.¹⁶⁷ The society was dedicated to all branches of knowledge, not just science. There was another essential difference between the Royal Society and the Philosophical Society. In light of the failures of earlier American societies dedicated to creation and dissemination of knowledge, Franklin depended on the patronage of fellow entrepreneurs within the city to fund this organization. In 1769, the preface to the first issue of the *Transactions of the American Philosophical Society*, written perhaps by Benjamin Franklin himself or at least influenced by him, stated, “knowledge is of little use when confined to mere speculation: But when speculative truths are reduced to practice...are applied to the common purposes of life; and when by these agriculture is improved, trade enlarged, the arts of living made more easy and comfortable...knowledge then becomes really useful.” The preface then further stated that the journal and the society generally were dedicated to enacting these precepts.¹⁶⁸ Because of this focus on commerce, societies like the American Philosophical Society often did not have the laboratory or equipment facilities needed to perform certain scientific experiments, and by the early nineteenth century, more specialized societies such as the Academy of Natural Sciences of Philadelphia (dedicated to geology and natural history) came into existence to meet this need.¹⁶⁹

¹⁶⁷ George Frick, “The Royal Society in America,” in *The Pursuit of Knowledge in the Early American Republic: American Scientific and Learned Societies from Colonial Times to the Civil War*, edited by Alexandra Oleson, and Sanborn C Brown. (Baltimore, MD: Johns Hopkins University Press, 1976), 70 – 71.

¹⁶⁸ American Philosophical Society. *Transactions of the American Philosophical Society*. (Philadelphia: American Philosophical Society, 1769), i – ii.

¹⁶⁹ Patsy Gerstner, “The Academy of Natural Sciences of Philadelphia,” in *The Pursuit of Knowledge in the Early American Republic: American Scientific and Learned Societies from Colonial Times to the Civil War*, edited by Alexandra Oleson, and Sanborn C Brown. (Baltimore, MD: Johns Hopkins University Press, 1976), 174.

In tandem with the foundations of the Academy of Natural Sciences, and later the Franklin Institute (dedicated specifically to experiments related to industrial application), the Lyceum movement was also influencing the American educational and scientific systems. Josiah Holbrook in Massachusetts envisioned a federation of lyceums around the country that would stimulate the founding of organizations to promote the growth of scientific and other knowledge in the United States. The lyceum movement did indeed lead to the founding of museums, popular scientific lecture circuits, institutes often affiliated with universities and museums, and, more indirectly, what became the U.S. public school system.¹⁷⁰ The institutions that branched from the lyceum movement were, however, incredibly decentralized into local systems and museums that often competed with one another. Furthermore, these institutions were often more interested in local scientific problems and often were not dedicated to any large national scientific project, a problem Alexander Dallas Bache bemoaned when he was elected to the Board of the Franklin Institute, named after his ancestor, Benjamin Franklin.¹⁷¹

There were some organizations though that were attempting to bring together local scientific interests and to combine them into a more nationally focused research agenda. One of the few government-sponsored research projects (at both state and national levels) were geological surveys. Many scientists were directly or indirectly employed by state geological surveys that sought to extract minerals and other natural resources. Later, the federal government would do similar types of surveys in what would become the U.S. Coastal Survey (headed by Alexander Dallas Bache) and the U. S. Geological Survey. The American

¹⁷⁰ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 8-9.

¹⁷¹ Bruce Sinclair, *Philadelphia's Philosopher Mechanics: A History of the Franklin Institute, 1824-1865*, (Baltimore: Johns Hopkins University Press,): 105-106.

Association of Geologists and Naturalists, founded in 1819, tried to bring together these scattered geologists into a national organization so that they could better coordinate their efforts.¹⁷²

In the 1830s, there were also efforts to unify science in Britain. During the Industrial Revolution, the Royal Society had been unable to sustain its preeminence in scientific advancements, particularly in industrial applications. Moreover, the Royal Society had become dominated by aristocratic families who often were averse to allowing scientists from lower classes to enter the society. Because of these problems within the Royal Society, many local industrial scientific societies began in large industrial centers such as Manchester and Birmingham to foster science in local towns and to provide opportunities for scientists who were not tied to the British scientific elite. Over time, these local societies recognized a need to communicate and to advance a more national agenda that was impossible to move through the Royal Society. Therefore, scientists from these local organizations founded the British Association for the Advancement of Science in 1831 in the City of York.¹⁷³

American science formed in response to the need for geologists from the American Association of Geologists and Naturalists to organize more broadly and from an awareness of how similar types of organization were establishing in Britain. On the one hand there were many scattered and competing scientific institutions spread around the United States; whatever centralized organization existed was primarily through state and limited national geological surveys. Like the British, Americans also felt the need to create a national agenda for the

¹⁷² Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 62-63.

¹⁷³ Jack Morrell and Arnold Thackray, *Gentlemen of Science: Early Years of the British Association for the Advancement of Science*. (Oxford: Clarendon Press, 1981), 54-58.

progress of science. Unlike Britain, where there was ample government patronage of science and a need for middle-class scientists to communicate their work without the constraints of a more rigid class system, Americans had little if any government or centralized patronage of their work but a class system that was much more fluid. As a result, the American Association for the Advancement of Science (AAAS) shared one of the same goals as its British counterpart, the creation of a national agenda for scientific endeavors, but was structurally and intellectually a very different organization.

Struggles for Power: The American Association for the Advancement of Science (AAAS) and Challenges to National Organization

In the 1840s it was not inevitable that the AAAS would even become the leader in American scientific organization. In the 1840s the American Philosophical Society was still a leader among scientific societies, though not nearly what it had been earlier in the century. Additionally, like the Royal Society, the American Philosophical Society had become largely dominated by the old families of Philadelphia and resembled a social club more than an actual organization dedicated to the advancement of knowledge.¹⁷⁴ The American Association of Geologists and Naturalists, though probably the largest scientific organization in the U.S. at the time, was also not representative of all of the scientists in fields not dedicated to mining and other geological pursuits. There was also some debate about what constituted science and whether it should be combined with medicine or other science-like professions. These debates were evident between 1840 and 1850. Before 1840, it was possible that the American

¹⁷⁴ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 29.

Philosophical Society could have emerged as the leader of science in America, or that another organization entirely would become the catalyst for the organization of Science in the U.S.

There were multiple attempts to establish a national organization for science in the United States. The first of these was through the American Philosophical Society which looked as if it would succeed early in the nineteenth century because it had the patronage of President Thomas Jefferson who was funding expeditions into the American frontier.¹⁷⁵ Not to be outdone, Boston had a rival group to the American Philosophical Society, founded somewhat later: the American Academy of Arts and Sciences, though this organization was initially less successful. Ultimately however, because the American Philosophical Society became dominated by Philadelphia's wealthy families and because later American presidents were less interested in science than Jefferson, the American Philosophical Society did not become the premier scientific in the U.S.

The second effort to nationalize American science began in 1838 when John Collins Warren (who later helped found the American Medical Association) wrote to the American Philosophical Society for help "for the formation of an American Association for the promotion of Science, and inviting the cooperation of the members of this society [the American Philosophical Society]."¹⁷⁶ Just ten days later the American Philosophical Society decided that it would be "inexpedient for the Society to engage in such an undertaking."¹⁷⁷ At almost exactly the same time as Warren's effort, John Poinsett tried to form the American Institution for the Cultivation of Science. Warren believed that his society failed because "a jealousy was

¹⁷⁵ *Ibid*, 2

¹⁷⁶ American Philosophical Society Minutes, October 5, 1838, American Philosophical Society Library.

¹⁷⁷ American Philosophical Society Minutes, October 16, 1838, American Philosophical Society Library.

awakened lest the proposed association should interfere with the Philosophical Society.”¹⁷⁸ The next attempt at a national association, the National Institute for the Promotion of Science, of which Bache was a corresponding member, was largely sponsored by the federal government and had little participation from non-government scientists. Therefore, those practitioners who were not a part of this very small group of scientists working on national projects felt particularly excluded and so were unwilling to lend their support.¹⁷⁹

The final effort to create a national association for science took place in 1840s, when the American Association of Geologists and Naturalists began to organize into a centralized scientific organization that ultimately was successful. Why was this effort successful? Largely it was due to the efforts of several scientists led by Alexander Dallas Bache. Bache was a member of a very prominent Philadelphia family and also had connections to important political figures. Bache’s great grandfather was Benjamin Franklin; his grandfather was Secretary of the Treasury, Alexander Dallas, and his uncle George Dallas was the Vice President of the U.S. Bache was the director of the United States Coastal Survey and also a professor of natural philosophy at the University of Pennsylvania. Bache’s connections and influence within the scientific community were substantial. One of Bache’s students was John Fries Frazer, later Provost at the University of Pennsylvania.¹⁸⁰ John Fries Frazer’s son, Persifor, was later one of the influential figures in the foundation of the American Chemical Society. Bache also had frequent contact with Benjamin Silliman, the editor of the *American Journal of Science*, the most influential scientific journal in the United States at the time, and with Joseph Henry, a professor at Princeton

¹⁷⁸ Edward Warren, *The Life of John Collins Warren, Vol. II*, (Boston: Ticknor and Fields, 1859): 2.

¹⁷⁹ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community*, 56-58.

¹⁸⁰ Alexander Dallas Bache Letter to John Fries Frazer, Box 3, Folder 5, Frazer Family Papers 1776-2004, University Archives and Records Center, University of Pennsylvania.

University and the first Secretary of the Smithsonian Institution. Bache was also one of the founders of the Smithsonian Institution and the first President of the National Academy of Sciences. Bache's connections spread even as far West as Indiana, where he asked a professor, Theophilus A. Wylie, a good friend and fellow classmate of John Fries Frazer and one of Bache's own students, for help in obtaining a post as director for the U.S. Coastal Survey.¹⁸¹

Bache was on the committee that made the decision to deny John Warren help in founding the American Association for the Promotion of Science. Bache also utilized his position as director of the U.S. Coast Survey, one of the largest government science projects at the time, to secure influence for scientists and to create a patronage network that made much scientific work in the U.S. dependent on a small group of people in Bache's circle.¹⁸² Bache also was one of the primary leaders behind moving the American Association of Geologists and Naturalists toward becoming the AAAS. Bache hoped to combine his efforts in creating national institutions of science such as the National Academies and to link those efforts to an already existing organization that had strong state and national government ties.¹⁸³ In all, Bache hoped to use the already existing network within the American Association of Geologists and Naturalists that already had members from nearly every state. Additionally, because many of those members were directly employed by the government, Bache used his government position to suppress rival (non-governmental) efforts to organize like those of Warren. Thus, Bache was able to attain his goal of creating a more centralized government structure for science.

¹⁸¹ Alexander Dallas Bache Letter Theophilus A. Wylie, Box 1, Folder 1, Theophilus A. Wylie Papers 1814-1992, University Archives, Indiana University.

¹⁸² Richard Hugh Slotten, "The Dilemmas of Science in the United States: Alexander Dallas Bache and the U. S. Coast Survey," *ISIS*, 84, no. 1 (1993): 34-36.

¹⁸³ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 96.

Brief History of the American Association for the Advancement of Science and the American Chemical Society

All of these developments in the organization of science help to form a picture of the origins for two of the earliest professional scientific associations in the United States. The first of these was the AAAS which was the first major professional scientific association to form in the United States in 1848. It formed from the American Association of Geologists and Naturalists which began in 1840. In 1847, some of the leaders of the American Association of Geologists and Naturalists, including both Alexander Dallas Bache and Louis Agassiz (perhaps better known for his opposition to the ideas of Charles Darwin) decided to reform the American Association of Geologists and Naturalists into a national scientific organization, AAAS.¹⁸⁴ Over time, the AAAS subdivided the organization into several sections, including the chemistry section, or section C, but also including sections for physics, engineering, astronomy, botany, and other fields, many of which later separated from the AAAS and evolved into other scientific professional associations.¹⁸⁵ AAAS still exists today, though with a modified mission, to “advance science, engineering, and innovation throughout the world for the benefit of all people.”¹⁸⁶

The American Chemical Society (ACS) was the first specialized professional scientific society in the U.S. ACS formed from a merger of section C of AAAS along with several smaller chemistry-related associations, including a group in Washington D.C., one in New York, and

¹⁸⁴ Sally Gregory Kohlstedt, Michael M. Sokal, and Bruce V Lewenstein, *The Establishment of Science in America: 150 Years of the American Association for the Advancement of Science*. (New Brunswick, N.J., Rutgers University Press, 1999), 10-12.

¹⁸⁵ Sally Gregory Kohlstedt, *The Formation of the American Scientific Community: The American Association for the Advancement of Science 1848-1860*. (Urbana, IL: University of Illinois Press, 1976), 211-213.

¹⁸⁶ “Mission and History,” *American Association for the Advancement of Science*, April 7, 2017, <https://www.aaas.org/about/mission-and-history>.

several local groups that were part of various universities or industrial interests. Officially the ACS formed in 1876. However, the initial society that formed in 1876 was largely dominated by chemists in New York City, and it was not until the 1890s that these disparate groups in D.C., New York, and perhaps most importantly, section C of the AAAS decided to merge into one large association dedicated to chemistry and separate from the AAAS.¹⁸⁷ As with AAAS, the ACS also still exists, and, similar to AAAS, now has a much broader mission to “advance the broader chemistry enterprise and its practitioners for the benefit of Earth and its people.”¹⁸⁸

¹⁸⁷ Charles Albert Browne and Mary Elvira Weeks, *A History of the American Chemical Society*, 81-82.

¹⁸⁸ “About ACS,” American Chemical Society, accessed May 18, 2017, <https://www.acs.org/content/acs/en/about.html>.

Alexander Dallas Bache and His Circle

AAAS' foundation was largely due to Bache's efforts at centralization of science.

Bache's work was supported by a growing national concern among American scientists who out of national pride wanted American scientists and scientific work to rival their European counterparts. In addition to the concern about American scientific scholarship being inferior to that of Europe, there was also a growing concern about education in the United States, and a desire among Americans to create a better national education system. Bache himself travelled to Europe to research the educational systems of other countries and wrote a report for the national government about the kinds of practices that he felt could be usefully applied in the U.S. Bache even implemented some of these ideas his into practice while serving on the board of Girard College, a local private school in Philadelphia.¹⁸⁹

Bache was not alone in his attempts to create American scientific institutions. He had the help of a small group of scientists that he termed the *Lazzaroni*. The term itself comes from an Italian term for hospitals serving the poor; Bache and his fellow scientists often used the term humorously to indicate that they were beggars looking for money to support their efforts. The group was quite informal but did have regular meetings that Bache recruited "for such service as the chairman [Bache] may assign."¹⁹⁰ Members at various times included John Fries Frazer, the Provost at the University of Pennsylvania and a former student of Bache's, as well as Joseph Henry, the Secretary of the Smithsonian Institution. These men had a substantial correspondence with Bache discussing the organization of science. Additionally, there were other

¹⁸⁹ Axel Jansen, *Alexander Dallas Bache: Building the American Nation Through Science and Education in the Nineteenth Century*. (New York: Campus Verlag, 2011), 126-128.

¹⁹⁰ Alexander Dallas Bache, "Letter to John Fries Frazer," 1856, Box 3, Folder 6, Item 8, Frazer Family Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

correspondents of Bache who may not officially have been a part of the *Lazzaroni*, but who were very well acquainted with the goals of the group and who often supported their efforts. Members of this outer circle included most notably Louis Agassiz, a professor at Harvard University and one of the most prominent scientists active in the U.S. at the time. The *Lazzaroni* had diverse opinions about how science should be organized in the United States, but generally had four concerns.

First, Bache and his colleagues believed that science was too localized and too focused on interests only relating to states (such as the geological surveys) or often to local industries (such as mining operations in individual towns and counties). They wanted to find ways to tie these institutions into a broader framework of education. More importantly, Bache expressly believed that science needed to have a national agenda and that there needed to be two types of institutions that did not yet exist in the United States. First, there needed to be a national scientific academy similar to the *Académie Française*; Bache later helped to found the National Academy of Sciences in 1861.¹⁹¹ The second part of Bache's vision was a national professional organization that would later become the AAAS.¹⁹²

Such institutions, according to the *Lazzaroni*, would need to have a clear definition of what sorts of science would be acceptable to practice at these national institutions. For Bache and his colleagues who were working in the context of a rapidly industrializing country, science needed to be of use to industry. Therefore, the focus of the *Lazzaroni* was on geology, chemistry, and other sciences that would be of use to companies seeking to exploit the newly

¹⁹¹ Axel Jansen, *Alexander Dallas Bache: Building the American Nation Through Science and Education in the Nineteenth Century*. (New York: Campus Verlag, 2011), 205.

¹⁹² Axel Jansen, *Alexander Dallas Bache*, 136.

discovered resources opening up throughout the U.S.¹⁹³ In order to achieve the manner of scientific expertise and research necessary to achieve this goal, Bache also recognized the need for greater specialization of science. Bache and the *Lazzaroni* struggled with this concept, however, because they also wished that all science should be centralized through organizations such as the National Academy of Sciences and the AAAS. This inherent contradiction would continue to surface until the organization and later separation of scientific associations like the ACS thirty years later.

In all, Bache and the *Lazzaroni* wanted to create a kind of aristocracy of science that would ensure only the best scientists received the kind of patronage and control over the scientific system that they believed would protect the integrity of science nationally.¹⁹⁴ The centralized, rigid, and hierarchical establishment that Bache, Frazer, Henry, and like-minded scientists envisioned was challenged as science expanded and other groups established other sources of authority within science, most notably the ACS, the first national specialized scientific society to form in the U.S.

University Reform

One of the first goals of the *Lazzaroni* was to reform educational institutions so that they could better realize scientific progress. In the early 19th century, prior to the formation of the AAAS, what scientific organization there was centered around the Lyceums of the United States. These organizations, were dedicated more to spreading of practical education, “to improve each

¹⁹³ Axel Jansen, *Alexander Dallas Bache*, 136.

¹⁹⁴ Hugh R. Slotten, *Patronage, Practice, and the Culture of American Science: Alexander Dallas Bache and the U.S. Coast Survey*. (Cambridge: Cambridge University Press, 1994), 32-33.

other in useful knowledge and to advance the interests of their schools.”¹⁹⁵ Additionally, there were other groups dedicated to social reform, including within schools led by people like Charles Fourier who preached a “doctrine of association” that united “association of interests, of efforts, of industry, of families, of classes, of nations.” Bache may have been aware of these efforts when he said “the principle of voluntary association by which in the United States we obtain some of our best results is derived from the country to which we owe our origin”¹⁹⁶ but Bache further suggested that there was a flaw within organizations such as Lyceums, “all the enterprises for the diffusion of knowledge are supported by a small portion of our population; and yet they are intended for the ultimate good of *all*, and should be supported by the *whole community*” (italics are Bache’s).¹⁹⁷ Furthermore, both Bache and contemporaries like Joseph Henry thought that there was another flaw in allowing organizations like lyceums to dominate the organization of science. According to Joseph Henry in a letter to Bache, “there are at this time thousands of institutions actively engaged in diffusion of knowledge in our country but not a single one which gives direct support to its increase.” Such increase, according to Henry could only be achieved by “original research, which requires patient thought and laborious and often expensive experiments,” and Henry encouraged government support for this “increase of knowledge.”¹⁹⁸ Bache was able to use his position in government, universities, and, most importantly, patronage to enact the vision he and Henry supported in a way that local lyceums were not because these

¹⁹⁵ Josiah Holbrook, *American Lyceum: Or Society for the Improvement of Schools and Diffusion of Useful Knowledge*, (Boston:Perkins & Marvin, 1829), 3.

¹⁹⁶ Alexander Dallas Bache, “Address delivered at the close of the Twelfth Exhibition of American Manufactures,” *Journal of the Franklin Institute*. (Philadelphia, Franklin Institute, 1842), 381.

¹⁹⁷ *Ibid*, 392.

¹⁹⁸ Letter Joseph Henry to Alexander Dallas Bache, September 5, 1846, Joseph Henry Papers, Smithsonian Archives, Smithsonian Institution.

local institutions did not have access to the money or people that Bache and other more prominent scientists of the time were able to access.

Perhaps the primary way that Bache was able to move his agenda for increasing knowledge was through his position in the government. Bache oversaw the U.S. Coastal Survey (a subdivision of the Department of the Navy) and in an unrelated letter mostly discussing his plans for the National Academy of Sciences, Bache reports to John Fries Frazer, “I have the honor to inform you that the Navy Department has referred to the National Academy of science for investigation and reports.” Furthermore, Bache requests that Frazer take a prominent role in writing these reports, “The Navy Department requests that on account of the expense and ‘public interest’ the subject may receive your early attention.”¹⁹⁹ With this rather simple letter, several aspects of Bache’s *modus operandi* become clear. First, Bache used his position in the government to aid his effort in founding the National Academy of Sciences. Second, he put members of his own circle in prominent positions both within the government, and, in this case, a joint effort between the government and the National Academy of Sciences. Thus, Bache utilized both the power of creating positions within the scientific community and his influence over centralized government institutions that he was creating for scientific work (such as the National Academies). By doing this, Bache started to centralize the scientific system more thoroughly.

Yet, there was one difficulty with Bache’s plan of action. Universities in the U.S. were by far the largest employer of scientists.²⁰⁰ By the time Bache was administering the U.S.

¹⁹⁹ Alexander Dallas Bache, “Letter to John Fries Frazer,” May 25, 1863, Box 3, Folder 5, Item 8, Frazer Family Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

²⁰⁰ Roger Geiger “The Rise and Fall of Useful Knowledge,” in *The American College in the Nineteenth Century*, edited by Roger Geiger. (Nashville, TN: Vanderbilt University Press, 2000), 154-157.

Coastal Survey, he was no longer teaching at a university. If Bache wanted to make his vision of a national scientific system possible, it would be necessary to connect university professors to a broader agenda. One way to do this was, of course, to utilize national organizations such as the American Association of Geologists and Naturalists (and later the AAAS). Another way was to take an active role in the reform of universities and scientific curricula.

Concern with university reform was widespread among leaders in higher education, particularly regarding curricular emphasis of science. J. Lawrence Smith, president of the AAAS said in 1874, about seven years after Bache's death, that, "our universities (or rather our so-called universities) are too numerous. Nowadays every college must have a scientific school attached.... it would be far better to have fewer scientific schools."²⁰¹ The reason Smith advocated for this reduction of scientific schools, according to Benjamin Silliman, was because scientific fields were "usually coupled with natural philosophy and natural history, and were never made the subject of personal laboratory training other than by didactic and demonstrative lectures" and that "the incumbents of professorial chairs made no contributions to the advancement of science or the stock of human knowledge."²⁰² Alexander Dallas Bache, as president of the American Association for the Advancement of Education, advocated for reform of the universities and specified that a university, "must lead in the advancement of science through the researches of its professors."²⁰³ Bache's statement highlights two important topics at the time: the importance of creating a scientific curriculum and the need for creating a research agenda within universities.

²⁰¹ F. W. Putnam, ed. *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1873), 3.

²⁰² Benjamin Silliman. "American Contributions to Chemistry," *American Chemist*, 5, no. 5 (1874): 92.

²⁰³ American Association for the Advancement of Education. *Proceedings of the Fifth Session of the American Association for the Advancement of Education*. (Hartford, CT: Press of Case, Tiffany and Company, 1856), 20.

There is also evidence that Bache was working to create such reforms within universities. In a letter from Louis Agassiz, bemoaning the situation at his own institution at Harvard, Agassiz wrote that reform ought to be done, “in accordance with the isolated efforts of the men who in our days advance science.” Yet Agassiz said, “no where are there symptoms that such an institution is likely soon to be founded. Yet the country which shall build the first will take the lead in the future progress of our science. I hope America may be wise and foresighted enough to do it.”²⁰⁴ Agassiz was in part asking Bache for help in establishing his own scientific agenda at Harvard that Agassiz insisted had “grown with the progress of science, there naturally been laid out under the influence of the scientific views prevailing at the time and though enlarged and modified in the course of time, they still all exhibit essentially the idea which has stimulated the exertions of the past century.”²⁰⁵ Part of Agassiz’s problem was that his fellow scientists at Harvard did not agree with Agassiz’s scientific views, and this letter is asking for Bache’s help in resolving the situation.

In the end, Agassiz received what he asked for. Bache used his contacts within the government and some former colleagues connected to Harvard to establish a museum of natural history (which Agassiz supervised) and that would advance the kind of science that Agassiz (and Bache) wanted to promote.²⁰⁶ Once again, Bache used his government influence and network to assist a member of his own circle. Later, Agassiz would return the favor by lending his own name and prestige to encourage the founding of the AAAS. Along with Henry Rogers and Benjamin Pierce, Agassiz wrote the new constitution for the AAAS, and in 1847 at the American

²⁰⁴ Louis Agassiz, “Letter to Alexander Dallas Bache,” August 5, 1856, Box 1, Item 49, A. D. Bache Papers, Philadelphia, PA: American Philosophical Society Library.

²⁰⁵ *Ibid.*

²⁰⁶ Axel Jansen, *Alexander Dallas Bache: Building the American Nation Through Science and Education in the Nineteenth Century*. (New York: Campus Verlag, 2011), 268-270.

Association of Geologists and Naturalists meeting, it was Agassiz who gave a speech stating, “[T]he men of science in this country have no cause to fear their European brethren. They have made more progress in the same departments than the scientific men of Europe.” Agassiz then gave an account of national associations in Europe and “it was then voted that the Association should be designated as the ‘American Association for the Promotion of Science.’”²⁰⁷

Geology and Industry

Beyond organizational aspects of American science though, there was also a concern among scientists about what constituted a proper object of study for science in the United States. It seems that geology was of primary concern. In a letter to John Fries Frazer, Frederick Fraley, one of the trustees of the University of Pennsylvania, wrote about the importance of geology in science and then proposed, “to recommend to the Trustees on Tuesday next to create the office of assistant prof of Chemistry and Nat. Philos...and to nominate Prof. Henry Morton to fill it.”²⁰⁸ Interestingly, geology was - at least in Fraley’s mind - a part of Chemistry and Natural Philosophy. Additionally, Henry Morton was at that time a researcher at the Franklin Institute, an institution dedicated to fostering industrial scholarship. Frederick Fraley was a businessman and the head of the Schuylkill Navigation Company (a rival to the company that would later build the Eerie Canal). Thus, one can see that John Fries Frazer seems to have had correspondence with figures who were interested in structuring science toward geological study and in ways that favored both geological study and industry.

²⁰⁷ Robert Jameson, ed., *The Edinburgh New Philosophical Journal* (Edinburgh: Adam and Charles Black, 1848), 151.

²⁰⁸ Frederick Fraley, “Letter to John Fries Frazer,” July 8, 1869, Box 3, Folder 4, Item 10, Frazer Family Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

Such ties to geology and industry are not surprising because Frazer had long had such interests. About twenty years earlier, during the foundation of the AAAS, Titian Ramsay Peale (a good friend of Frazer's and an influential figure in Philadelphia society) was himself seeking patronage from both Frazer and Alexander Dallas Bache. Peale later received that support when he obtained a job in the U.S. Patent Office. Peale was also following the developments of the American Association of Geologists and Naturalists and its progression into the AAAS. Peale wrote to Frazer, "The geological association [American Association of Geologists and Naturalists] seems to get along swimmingly...The National Institute for the promotion of science – patronized the geologists and invited them to a meeting a few nights since to show the multitude of their correspondence."²⁰⁹ Peale provides evidence again that geology was an important part of American science in the mid-nineteenth century. More importantly, Frazer's interest in promoting geology seems to be tied to the industrial interests of important university Trustees such as Frederick Fraley

Frazer however was not alone in his ties both to industry and geology. Contemporaries of Alexander Dallas Bache also commented on how influential this period at the Franklin Institute was in his life. In two eulogies delivered on Bache's death, Joseph Henry, Secretary of the Smithsonian Institution, and Benjamin Gould, president of the AAAS, stated that "the early period of his [Bache's] life, including that which preceded his first call to Philadelphia, was almost wholly devoted to the improvement of the mechanical, or the 'doing' faculties of his mind,"²¹⁰ and that "the influence of the Franklin Institute, in giving to Bache's first researches an

²⁰⁹ Titian Ramsay Peale, "Letter to John Fries Frazer," May 15, 1844, Box 1, Item 37, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

²¹⁰ Joseph Henry, *Eulogy on Professor Alexander Dallas Bache*, 18.

especially practical character, is very noticeable at this period.”²¹¹ Bache also reflected in his own writing this emphasis on practical and applied knowledge, “[I]ncreased production, whether in agriculture or manufactures, is so obvious and powerful a source of prosperity to a country, that we naturally look with interest upon every circumstance which may effect it.”²¹² Thus in the early period of Bache’s life, he was very focused on application of knowledge, particularly as it is useful to industry in Philadelphia.

When Bache helped to found the AAAS, his interest in practical knowledge continued. In his presidential address to AAAS, Bache acknowledged that, “the calls for mechanical knowledge, and for the applications of physics, of mathematics, and of natural science, have, without a doubt, thrown us irresistibly into the career we are now following.”²¹³ Moreover, Bache’s emphasis on practical knowledge was not unique to him. Benjamin Silliman, in his preface to the *American Journal of Science*, stated that, the journal “will be a leading object to illustrate American Natural History, and especially our Mineralogy and Geology. The applications of these sciences are obviously as numerous as physical arts and physical wants; for not one of these arts or wants can be named which is not connected with them.”²¹⁴ In other words practical knowledge is not only important in the organization of science, such as in the AAAS, but in the diffusion of science within its journals.

²¹¹ Benjamin Apthorp Gould, *An Address in Commemoration of Alexander Dallas Bache*. (Salem, MA: Essex Institute Press, 1868);: 7.

²¹² Alexander Dallas Bache, “Address delivered at the close of the Twelfth Exhibition of American Manufactures”, 380.

²¹³ Spencer F. Baird, ed. *Proceedings of the American Association for the Advancement of Science*. (New York: G. P. Putnam, 1852), xliii.

²¹⁴ Benjamin Silliman, “The Plan of the Work,” *American Journal of Science*, 1, no. 1 (1818), v.

Division of Knowledge

Geology and industry, therefore, were primary drivers of American science during the mid-nineteenth century. Though industry may have been one of the most important outside forces pushing the formation of the AAAS, there was another still another significant factor driving their creation: power, especially between competing groups both within AAAS and within the scientific field more generally. There was a struggle for control happening within the early years of scientific organizing in the U.S. For the AAAS, the battle was between several rival groups all of which could lay claim to scientific knowledge. Such groups included those who were more interested in understanding chemical compounds within natural resources being created by mining, as well as those who were interested more in creating geological surveys for the purpose of generating maps, navigational charts, and topographical instruments for creating roads and other infrastructure. Bache and his contemporaries never seemed to completely resolve these differences of opinion between rival groups. On the one hand they encouraged specialization as a natural outgrowth of scientific endeavors. On the other hand, they also tried to make the centralized institutions that they were creating the main conduit through which all these rival groups had to operate.

Alexander Dallas Bache, in his 1852 presidential address to the AAAS strongly urged his fellow scientists to specialize and not to be too general in their knowledge because, “while a general knowledge of various branches of science is useful in developing even a single branch, it is still certain that subdivision is essential to advancement.”²¹⁵ In fact according to Bache, over-generalization had led to some abuses in scientific practice within the United States. He claimed,

²¹⁵ Spencer F. Baird, ed. *Proceedings of the American Association for the Advancement of Science*, xlv.

“[T]he absence of a minute subdivision in the pursuit of science, the prevalence of general lecturing on various branches, the cultivation of the literature of science rather than of science itself has produced many of the evils under which American science has labored, and are now passing away.”²¹⁶ Nor was this desire for subdivision within science a mere wish for the advancement of knowledge. For Bache, the need for specialization was at the very heart of the credibility of science, “[O]ur real danger lies now from a modified charlatanism, which makes merit in one subject an excuse for asking authority in others, or in all.”²¹⁷ In other words, to have a small amount of knowledge in a large number of fields, gave practitioners a false credibility that could lead to “charlatanism.”

Bache’s descendants in leadership at the AAAS shared similar concerns, but at the same time advocated for a power structure that would separate itself from organizations such as the AAAS. For instance, J. Lawrence Smith, president of both the AAAS and the ACS, was particularly known for his concern both with pure science and for separating chemistry as a unique branch of scientific endeavor. Silliman in his biography of Smith noted that as a professor at the University of Virginia, Smith “confined his lectures to chemistry proper, leaving physics to the professor in charge of that branch. This he did, I believe, of set purpose, with the result of his giving more chemistry in eight months than his predecessors had done, nominally, in nine.”²¹⁸ Additionally, in his presidential address recorded in 1873, Smith called for “pure science,” and particularly encouraged scientists to remain pure because “any chemist who would quit his method of investigation, of marking every foot of his advance by some indelible imprint,

²¹⁶ Ibid.

²¹⁷ Ibid, xlv.

²¹⁸ Silliman, Benjamin. *Memoir of John Lawrence Smith, 1818-1883*. (Washington, D.C.: National Academy of Sciences, 1886), 231.

and go back to the speculations of Albertus Magnus, Roger Bacon, and other alchemists of former ages, would soon be dropped from the list of chemists and ranked with dreamers and speculators.”²¹⁹

Bache himself was quite preoccupied with the political problem that he feared could lead to the dissolution of the very organizations he was trying to create. As early as 1846 Bache wrote to Frazer, “Can it be that the Institute [precursor to the National Academy of Sciences] has been carried with the political vortex? I trust not; for however divided the sentiments of the members may be, the institute should be kept for science.”²²⁰ Clearly before the National Academies were even formally established, Bache was having difficulty keeping its members together for an overall agenda of promoting science which Bache believed needed to be unified. Yet even Bache’s supporters recognized this dream of creating a centralized system was facing difficulty. Joseph Henry wrote to John Fries Frazer about Bache’s efforts saying, “[T]he scientific council are considered mere partisans in general in which each side is striving for victory instead of endeavoring to do what is right.... They have applied the power vested in them to gratify their own malicious feelings rather than to carry out the object of the trust of the advance of science.”²²¹

Creating an Aristocracy of Science

With these divisions among partisans, there was one important question for American scientists at the time. Who controls science, and which groups should shape its future? There

²¹⁹ Frederick W. Putnam, ed, *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1873), 18.

²²⁰ Alexander Dallas Bache, “Letter to John Fries Frazer,” November 9, 1846, Box 1, Item 66, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

²²¹ Joseph Henry, “Letter to John Fries Frazer,” October 16, 1858, Box 4, Item 38, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

were several contenders for dominance, all of whom Bache and his supporters needed to satisfy. These included the government, specialists within the AAAS and the National Academy of Sciences, and even members of Bache's own circle of *Lazzaroni* and closely affiliated individuals. These competing groups of scientists did seem to share one thing in common, however. All of them believed that a small group of people should control scientific endeavors. It was simply a matter of which small group controlled science more than the others. Therefore, at least in American science during this period, it was clear that there needed to be a kind of aristocracy for scientific truth, the problem was who was a part of that aristocracy and how one should be able to enter it.

One of the most noticeable features of the formation of the AAAS was the small number of people who engaged in the creation of the organization, centering mostly around Bache and the scientists affiliated with him. Joseph Henry said that Bache's "marked characteristic was the control" that, according to Henry, allowed Bache, "to pursue with unrelenting perseverance the course he had marked out."²²² Both Henry and Bache shared a desire for control and Henry once wrote to Bache that they ought to influence the *American Journal of Science* by creating "a board of collaborators who should have the principle if not the entire control of different departments."²²³ The influence of these central figures and the small number of people surrounding them differentiates science from some other professional groups of the time such as law and medicine.

²²² Joseph Henry, *Eulogy on Professor Alexander Dallas Bache*, 4.

²²³ Letter Joseph Henry to Alexander Dallas Bache, November 12, 1843, Joseph Henry Papers, Smithsonian Archives, Smithsonian Institution.

There was another reason Bache and his supporters had for desiring to control American science. They feared inferior amateur scientists could dominate a large national organization. Upon returning from the British Association for the Advancement of Science in 1838, Joseph Henry wrote to Alexander Dallas Bache about the control that aristocrats had over the proceedings because “otherwise *third* and *fourth* rate men would soon control the affair and render the whole abortive and ridiculous” (emphasis Henry’s). Henry also commented on the attempts to create an association in the United States: “a promiscuous assembly of those who call themselves men of science in this country would only end in our disgrace.”²²⁴ Thus for Henry at least the issue the most important issue was to control the organization.

The Association of American Geologists and Naturalists gave Bache and his colleagues a good opportunity to organize within a society that included a broad membership base and whose leadership largely came from the *Lazzaroni*. With nearly every U.S. state having a geological survey and many prominent scientists throughout the country being involved with those surveys, the Association of American Geologists and Naturalists had a broad base upon which to draw potential members. Additionally, members of the Association of American Geologists and Naturalists - such as Benjamin Silliman, Alexander Dallas Bache, and Joseph Henry - saw an opportunity to use the influence of Louis Agassiz. Titian Ramsay Peale wrote to Alexander Dallas Bache that, “his [Agassiz] opinion of our labors would be of great service – and we want such impressions as he could make to save us from ‘our friends’ (both political and naval.) – when I say us, I mean the naturalists.”²²⁵ Interestingly, Peale recognized two points about the

²²⁴ Letter Joseph Henry to Alexander Dallas Bache, August 9, 1838, Joseph Henry Papers, Smithsonian Archives, Smithsonian Institution.

²²⁵ Titian Ramsay Peale, “Letter to John Fries Frazer,” October 30, 1846, Box 1, Item 65, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

organization of science in this period. First, he identified Bache's relationship with Agassiz and the prestige it brought. Second, Peale was demonstrating an already existing tension between government interests and those of scientists, particularly naturalists.

The tensions between the two groups surfaced even during Bache's attempts at organizing the AAAS. Titian Ramsay Peale hinted at the tension in one of his letters, long before any actual issues surfaced, "In naval matters knowledge is always known positively to exist in proportion to rank, and where power is given it is treason to dispute the fact that birds are not fish."²²⁶ About ten years later, government and non-government scientists had a rather notable dispute over the actions of Benjamin Apthorp Gould who was also one of the founders of the AAAS and the director of the U.S. Naval Observatory (then part of the U.S. Coastal Survey and under the patronage of Bache). Government trustees fired Gould from his position, with the support of several scientists within AAAS largely over management issues. Government officials believed they should control the work of the observatory; Gould believed otherwise. Joseph Henry wrote to Bache that, "As members of the scientific community we have been treated shamefully and the trustees in their endeavor to destroy the character of Dr. Gould have brought the observatory to the brink of ruin."²²⁷ Even Bache himself commented on the situation and his anger about it. In a letter to another colleague who was asking about taking a position at the U.S. Naval Observatory, Bache advised, "You ask me to advise you what you ought to do in case the place is offered to you. I say now to decline it. The men who drove out Dr. Gould of the Council are still in charge and nothing is to be expected then different from what they shared in

²²⁶ Titian Ramsay Peale, "Letter to John Fries Frazer."

²²⁷ Joseph Henry, "Letter to John Fries Frazer," October 16, 1858, Box 4, Item 38, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

that case.”²²⁸ The main division that this incident reflects is a growing tension between Bache’s circle and the government instruments of power that Bache used to achieve his ends.

Yet, the Gould incident also demonstrates another problem, members of the AAAS had supported the removal of Gould, which led Gould to write that there ought to be an even more elite group of scientists in control of American science independent of the AAAS. Even before being removed from his position at the U.S. Naval Observatory, Gould wrote to John Fries Frazer “Do you remember in one of our chronic flights of opinion about the “Am. Ass. Adv. Sci.” (which does not signify Amazing Asses Adverse to Science) you broached an idea that more could be done by one good feed with decent fellows than by an immensity of public howling I set out to put the scheme into operation and found everybody pleased with the idea and nobody ready to act.”²²⁹ Gould then listed a set of names of these people who had already accepted (including Bache) and insisted that “future participants only to be invited by unanimous consent”²³⁰ This would seem to indicate that within about ten years from the foundation of the AAAS, there was discord between Bache and the leadership of the AAAS, and there was a feeling among Bache’s circle they needed to assert more control over American scientific endeavors.

The incident with Gould resulted in one other interesting development. After Gould left, Joseph Henry departed from his previous custom of spending large amounts of money on geographical maps and surveys, and wrote to H. B. Anthony in response to a letter asking for publishing funds, “I have never been an advocate of a lavish expenditure on the publication of

²²⁸ Alexander Dallas Bache, “Letter to J. M. Schofield,” September 24, 1860, Box 1, Item 60, A. D. Bache Papers, Philadelphia, PA: American Philosophical Society Library.

²²⁹ Benjamin Apthorp Gould, “Letter to John Fries Frazer,” November 22, 1856, Box 3, Item 96, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

²³⁰ *Ibid.*

immense editions of scientific works by the general government.”²³¹ Henry continued, “I know that in some cases matter has been introduced into reports for the sake of swelling their size which did not form a part of the researches and which was not a new addition to knowledge.”²³² Though there is unlikely to be any direct connection to these statements and to Gould’s removal, Henry seems to have recognized that government publication of science had not led to the advancement of knowledge (or at least not to Henry’s satisfaction), and seems to have thought that publication of science should come from a different avenue.

Tensions between the government, AAAS, and the associations’ multiple specialized branches were a major weakness in the aristocracy of science that Bache and his colleagues endeavored to create. Even within Bache’s lifetime, Gould and others lost their positions within the government and were advocating to create institutions more firmly under their control than the ones they themselves had worked to create. Furthermore, Bache himself seemed to recognize the importance of specialization necessary serve the industrial needs of American society. Yet, Bache seemed to fear the fracturing of science, and believed that it had to be centralized through a trustworthy and national authority. About ten years after Bache’s death, the struggle for power over how that authority would be structured was tested, and the tension between specialization and national authority took a different turn.

²³¹ Joseph Henry, “Letter to H. B. Anthony,” March 21, 1861, Box 1, Item 20, Joseph Henry Letters, Philadelphia, PA: American Philosophical Society Library.

²³² *Ibid.*

American Chemical Society (ACS)

The same inherent tension of centralizing scientific authority while allowing subspecialties to work on narrower problems did not dissipate when the first specialized professional scientific society in the U.S. formed in the later part of the nineteenth century. The ACS is, in a way, very similar to the AAAS. Yet, even though the beginnings of both organizations seem comparable, chemistry followed a very different course in creating its professional organization. In the same way that Bache and his circle drove much of the institutionalization of science in the mid-nineteenth century, a very small group of founders was responsible for establishing the ACS. The situation was, however, quite different. Rather than seeking instruments of power through the government, as Alexander Dallas Bache and Joseph Henry had done, these chemists were more closely attached to a well-developed chemical industry. Therefore, even though Bache and his colleagues also believed that science should be tied to the practical needs of business, these early ACS leaders were even more interested in serving the needs of industry. The founders of the ACS also dealt with smaller, well-organized, and competing chemistry organizations, a situation different from Bache. Rather than refusing help to competing organizations such as the American Association for the Promotion of Science in the late 1830s, the leaders of ACS merged with several professional chemical societies when they created their organization. Therefore, these two societies (AAAS and ACS) were similar at the time they were established. Both had similar founding principles; both were started by a small number of leaders, and the coordinators of both societies felt the need to centralize authority. Nonetheless the methods the organizers of AAAS and ACS used to found their societies were quite different.

The problems of the ACS, principally the subdivisions within the discipline also seem quite similar to the issues with which Bache and the founders of the AAAS struggled. Many subsections of the ACS began to form even during the organization's earliest years. Unlike the organizers of the AAAS though, the managers of the ACS seem very preoccupied with informational issues. Even before there was any formal society, officers of various committees discussed the need to create libraries and to start journals and proceedings to share scientific discoveries.

By comparing the similarities and differences between the two organizations one can see how a link between scientific organization and scientific communication began to establish a nascent scholarly communication system beginning as early as the 1880s. The professionalization of chemistry, as with science more generally, was led by a small group of people who were very interested in industrial progress. This group wanted their authority centralized, but ultimately the chemists were more successful in centralizing their authority within the ACS. Why? Perhaps the answer lies in the differences between the institutionalization of the AAAS and the ACS. ACS created more of a union between different societies of chemistry. AAAS created a single organization and attempted to suppress rival societies. Leaders of ACS also recognized a need for disseminating and sharing information that does not seem to have been a concern of the organizers within AAAS.

Aristocrats and Industry

Early on, many of the leaders within the ACS reiterated the sentiments of the leaders within the AAAS. In part this is not surprising because many of these leaders were also officers within the AAAS. William Draper, the inaugural president of the ACS and a professor at New

York University said in his presidential address reported in 1876 that “The progress of science among us very largely depends on two elements: First, on our educational establishments. Second on our scientific societies.”²³³ Draper was, therefore, recognizing, like Bache, the central place of universities in organizing and professionalizing science. In the same speech, Draper concluded his address by encouraging universities to reform and abandon the teaching of Latin and Greek and to pursue a “modern” course which embraced science, and he discussed the influence of associations like the American Philosophical Society and the AAAS in shaping the ACS.

Perhaps the most apparent similarity between these two organizations is the very small number of people involved in the formation of ACS, many of whom had also been instrumental in either the foundation of the AAAS or had been leaders in the AAAS at one time. In 1874, about thirty years after the creation of the AAAS, a small group of chemists met to celebrate the centenary of Joseph Priestley’s discovery of oxygen. Benjamin Silliman, William Draper, and many of the important figures in the early history of the ACS were present at this meeting. During that meeting Persifor Frazer (son of John Fries Frazer) proposed that a national chemical society be created. J. Lawrence Smith (former president of the AAAS and later president of the ACS) opposed this idea and suggested creating a more permanent section within the AAAS because there simply were too few chemists, he believed, to form a national society, and the money required to form a sustainable association was too high. Other figures present at that

²³³ American Chemical Society. *Proceedings of the American Chemical Society*. (New York : Trow's Printing and Bookbinding Company, 1876), 135.

meeting included later presidents of the ACS and vice-presidents of the chemistry section of the AAAS.²³⁴

What Smith was not aware of, however was that much of the agitation for the creation of a national society for chemistry came from within the AAAS's chemistry section itself. Albert Prescott, a professor at the University of Michigan, president of the ACS (1886) and later president of the AAAS (1891), wrote a report published in the *Proceedings of AAAS* (1889) encouraging a national organization under the auspices of the AAAS: "To organize for further union, chemists must cherish the growing chemical aggregation in Section C [AAAS's chemistry section], now of permanent standing and great social advantage, and an alliance with this Section, carefully framed for mutual benefit, must be fundamental in the new organization."²³⁵ The following year Frank W. Clarke, chief chemist of the U.S. Geological survey, became the chair of that committee and reported on a circular that the committee sent to universities and chemists around the country in order to determine the feasibility of this plan. In Clarke's report in *AAAS Proceedings*, he suggested holding a conference "to decide how a national organization can best be brought about, and the long-desired union of all American chemists made a practical reality."²³⁶

There were two conferences held in Philadelphia in 1890 (in conjunction with the ACS) and Washington, D.C. in 1891 (in conjunction with the AAAS). The meeting in Washington, under the leadership of George Barker (president of the ACS in 1891 and formerly vice-president of the AAAS chemistry section in 1876), recommended in the *Journal of the American Chemical*

²³⁴ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 10-15.

²³⁵ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1889), 36.

²³⁶ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*, 141.

Society (1891) “the union, under the name and organization of the American Chemical Society of all the members of the different societies represented, and the reorganization of local chemical societies as local sections of the American Chemical Society.”²³⁷ The same year, Frank Clarke reported in the *Proceedings of the AAAS* (1891) that “a conference of representatives of ten organizations had been held. The representatives of the American Chemical Society had indicated a willingness to make the changes in their constitution necessary to adapt it to the requirements of American chemists in general, and a unanimous vote of all delegates present favored a union under the charter of that body.”²³⁸

It was not only leaders within the AAAS, however, who were instrumental in creating the aristocracy of science within chemistry. There was another group of chemists who were also instrumental in the creation of the ACS, many of whom were also a part of the AAAS, but also dominated much of the ACS’ early history.²³⁹ The New York Chemists club, an organization that continued to exist into the twentieth century, formed an additional small network of chemists who dominated much of the professional organization’s early history. The influence of the New York Chemists Club was attested to by one of the ACS’ presidents, George Barker, who commented that of all the groups who influenced ACS’ founding none, “had done more for the society” and that their role, “fulfilled beyond the expectancy of his most hopeful friends.”²⁴⁰ In fact, many of the early presidents and leaders of the ACS had originally been officers in the New York Chemists’ Club and this New York Group fomented at least some of the skepticism that a

²³⁷ A. A. Breneman, ed., *Journal of the American Chemical Society*. (New York: John Polhemus Printing Company, 1891), 191.

²³⁸ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1891), 179.

²³⁹ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 15-16.

²⁴⁰ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, January 5, 1900. Philadelphia, PA: Science History Institute, Othmer Library.

national organization was feasible, an opinion expressed by influential figures like J. Lawrence Smith.²⁴¹

In some ways, the Chemists' club seems to have had some of the same goals as Benjamin Apthorp Gould and his suggestion that a "good feed" among friends would be more useful to science than large professional meetings. The invitation to join the New York Chemists' Club emphasized that it, "does not wish however to limit its activity to the strictly practical aim its founders had in view when started. It is desirous of cultivating still further the social element among all those interested in chemical research."²⁴² This emphasis on creating a social group of chemists continued into the late nineteenth century. Charles Dudley, the President of the ACS in 1896 and principal chemist for the Pennsylvania Railroad addressed the New York Chemists' Club by saying, "It has been one of my pleasant thoughts that I was fortunate enough to have joined the Society when there was only a New York Section. It has been a rare pleasure to attend the meeting of the New York Section, and I would like to congratulate you on two points. First the advantage that comes to you being a member of a coterie."²⁴³ Dudley was emphasizing the advantage small group of chemists at this group, and the advantage of fostering this "coterie" of colleagues.

Additionally, as in the case of Bache and the formation of AAAS, the influence of industry continued to be present in the creation of the ACS. In the *Proceedings of AAAS* (1886), vice-president Harvey Wiley wrote, "Men of affairs often criticise science because it is not practical. ... I desire to say a few words respecting the economic aspects of Agricultural

²⁴¹ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 26.

²⁴² Chemists Club, New York, NY. *Miscellaneous records of the Chemists' Club*. Box 37, Folder 1, Item 4, Philadelphia, PA: Science History Institute, Othmer Library.

²⁴³ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, March 6, 1896. Philadelphia, PA: Science History Institute, Othmer Library.

Chemistry.”²⁴⁴ His address then discussed the impact of chemistry on the farming industry. Two years later, the *Journal of the American Chemical Society* (1888) reported “the outcome of the visit of the Society of Chemical Industry to the works of the above-mentioned company [Noble’s Explosives Company],”²⁴⁵ and the journal often included entire sections dedicated to industrial chemistry. Clearly, therefore, many of these important figures helping to found and administer the ACS were concerned with issues relating to industry.

Later leaders of the ACS also continued supporting practical knowledge and industry. J. Lawrence Smith was also the president of the Louisville Gas Works, various mineralogical exploratory companies that helped to discover mines in Turkey and the United States, and according to Silliman, Smith “established a laboratory for the production of chemical reagents and of the rarer pharmaceutical preparations, in which enterprise he associated himself with Dr. E. R. Squibb, whose fame as a successful worker in pharmaceutical chemistry is well known.”²⁴⁶ Charles Chandler founded the New York section of the Society for Chemical Industry in 1896, and, because of his influence within the ACS, established links between those two organizations. Browne and Weeks in their history of the ACS even suggest that the *Journal of the American Chemical Society* attempted to create a “balanced presentation of every phase of chemical industry.”²⁴⁷ Because of the early leaders of the ACS’ stronger ties to industry, the link between ACS and chemical companies was much more solid than the industrial ties that Bache or his colleagues had created for AAAS.

²⁴⁴ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1886), 125.

²⁴⁵ A. A. Breneman, ed., *Journal of the American Chemical Society*. (New York: John Polhemus Printing Company, 1888), 116.

²⁴⁶ Silliman, Benjamin. *Memoir of John Lawrence Smith, 1818-1883*, 235.

²⁴⁷ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 89.

A Union of Societies

Despite the similarities between groups like the AAAS and the ACS, there were also some significant differences. Foremost among them were different strategies for in working with competing groups. Bache discouraged colleagues like Warren who were interested in creating national societies that might be competitors to Bache's own designs. The founders of the ACS utilized a different strategy, perhaps because of the large number of chemistry-related groups already in existence at the time of ACS' foundation. One of the largest groups of practicing chemists resided at the Franklin Institute of Philadelphia which had its own journal and its own section specifically about chemistry. The *Journal of the Franklin Institute* discussed whether the Institute should support the ACS's attempt to form a society separate from the AAAS. It said that the Franklin Institute's Chemistry section formed a committee "in response to a request ...from Mr. A. A. Breneman, chairman of the committee of arrangements of the American Chemical Society"²⁴⁸ and that the Franklin Institute sent representatives to the ACS meeting in Philadelphia. Incidentally, Persifor Frazer, who Browne and Weeks credit with having the idea for the creation of a national chemical society, was one of the editors of the *Journal of the Franklin Institute*.²⁴⁹

The Franklin Institute was one of many such groups and university departments that the founders of ACS engaged while forming their own professional society for chemistry. For example, there was a group called the Chemical Society of the University of Michigan consisting of sixty members listed in the *Journal of the American Chemical Society* (1891). This organization was at least influential enough to be represented in a meeting of ten societies to

²⁴⁸ Persifor Frazer, Edwin J. Houston, Theodore D. Rand, Coleman Sellers, and H.W. Spangler, eds. *The Journal of the Franklin Institute*. (Philadelphia, PA: The Franklin Institute, 1891), 141.

²⁴⁹ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 12.

discuss the formation of a national chemical society.²⁵⁰ Similarly the Chemical Society of Philadelphia was headquartered at the University of Pennsylvania where Draper, Benjamin Silliman, and many other influential figures in the field were educated. Universities created quasi-professional societies within their own institutions and in turn the graduates of those universities created larger national entities that likely mimicked many of the characteristics of the societies within their home universities (such as journals, proceedings of chemical experiments, and forms of governance). There were also some scattered groups relating to professional chemistry throughout the U.S., and a sampling of them can be found in a report in the *Journal of the American Chemical Society* (1891) summarizing a meeting held in Washington, D.C. which included representatives from the Association of Official Agricultural Chemists, the Chemical Section of the Franklin Institute (in Philadelphia), the Washington Chemical Society (Washington, D.C.), The Chemical Section of the Brooklyn Institute, the Louisiana Sugar Chemists' Association, the Chemical Society of the University of Michigan, the Cincinnati Chemical Society, and the Manufacturing Chemists' Association of the United States.²⁵¹

The effectiveness of such local and national groups was one of the reasons some members of the ACS and the AAAS questioned the need for a national chemistry society. In the *Proceedings of the American Chemical Society* (1876), one of the attendees at the meeting noted that the New York Lyceum of Natural History which had just reorganized itself into the New York Academy of Arts and Sciences had a section specifically devoted to Chemistry, and, at

²⁵⁰A. A. Breneman, ed., *Journal of the American Chemical Society*. (New York: John Polhemus Printing Company, 1891), 194-195.

²⁵¹ American Chemical Society. *Proceedings of the American Chemical Society*. (New York: Trow's Printing and Bookbinding Company, 1876), 194-195.

least for practitioners in the New York area, such an organization should be sufficient.

Furthermore, they argued that a national organization such as the ACS might hinder the New York Academy of Arts and Science's progress by competing with it.²⁵²

In 1876 Charles Chandler, professor of chemistry at Columbia University who was also present at the 1874 meeting, circulated a letter to these groups throughout the country asking them to join the ACS and be a part of that national movement. George F. Barker, then vice-president of the chemistry section of the AAAS noted in his speech recorded in the *Proceedings of the AAAS* (1876) that "Another event has taken place, which is of especial interest to the members of this subsection. I allude to the formation of the American Chemical Society. The movement originated in the city of New York and the preliminary meeting was held on the 6th of April last...- The most cordial relations exist between the society and this subsection."²⁵³ Though several chemists did join the ACS, it never really became a national society until 1891 when the Chemical Society of Washington, the ACS, and the AAAS' section on Chemistry, along with several smaller organizations, decided to merge.

The early minutes of the New York Chemists consistently affirmed the desire to create mergers between ACS and other chemistry and scientific related groups. In 1892, the minutes of the New York Section of the ACS reported "that progress was being made toward obtaining a permanent home for the Allied Societies" and that they desired, "to meet in joint session with the other Societies of the Alliance."²⁵⁴ Two years later the New York Chemists resolved "that this Section join with the other Societies constituting the Scientific Alliance in in an appeal to the

²⁵² *Ibid*, 10.

²⁵³ American Chemical Society. *Proceedings of the American Chemical Society*. (New York : Trow's Printing and Bookbinding Company, 1876), 86.

²⁵⁴ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, October 7, 1892. Philadelphia, PA: Science History Institute, Othmer Library.

several Societies and Associations with which it is in correspondence both in this country and in foreign lands.”²⁵⁵ Later, in George Barker’s address to the same group of chemists, Barker praised them for their dedication to, “a unification of interests and increase of membership of the society.”²⁵⁶ Clearly, union between groups was an important concern both for the national leaders of the ACS, but also in the eyes of the small groups of chemists who desired to create their own professional identity outside of national scientific structures such as the AAAS.

Subdivision

In part because of this union of different societies and interests, the ACS, like the AAAS, faced the possibility of subdivision and fracturing between competing subspecialties. Later presidents of the ACS expressed such concerns. At the same time the leadership of the ACS was adamant that non-chemistry (particularly physics) topics be excluded from ACS discussions and ACS leadership pressed for subdivision within their professional field. For them it was also important that chemical knowledge be separate from other branches of science. George F. Barker, in his 1891 presidential to the ACS argued for setting boundaries between the disciplines of physics and chemistry when he said “If it be true that in both physics and chemistry, taken separately, precision of thought and consequent precision of language are dependent upon a precise use of terms, how much more true is it in that limiting region which lies between them.”²⁵⁷ Barker was also incredibly influential in the early years of the ACS and was one of the driving forces behind the merger of multiple chemical associations into the ACS. As president

²⁵⁵ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, April 12, 1894. Philadelphia, PA: Science History Institute, Othmer Library.

²⁵⁶ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, January 5, 1900. Philadelphia, PA: Science History Institute, Othmer Library.

²⁵⁷ A. A. Breneman, ed., *Journal of the American Chemical Society*. (New York: John Polhemus Printing Company, 1891), 12.

of the ACS, Barker oversaw the meetings that led to a revised constitution and effectively created a national chemistry organization that incorporated these local associations in 1891.

At the same time, factions among the leadership within ACS were to pushing for the exact opposite of union between local and national chemical societies. For instance, in the New York Section of the ACS, only a few years after the executive committee was resolving to ally with different groups, the president of the section said, “I understand that the members of the Executive committee are all in favor of withdrawing from the Alliance and if it should happen that the men who are further appointed in this committee should be equally divided there would be a large majority on that side.” He also reported that, “They have already investigated the matter for several years and have their minds made up.”²⁵⁸ Therefore it seems that this struggle between unification on the one hand, and decentralization on the other happened throughout the 1890s, before the ACS formally unified with other prominent chemistry groups in 1897.

The origins of this debate over centralization also appear to have been longstanding. Similar political maneuvering featured in the formation of the ACS throughout the 1880s and 1890s. There are some hints of divisions within the official reports of the AAAS. Frank Clarke in his report in the *Proceedings of the AAAS* (1890) summarized an earlier report that favored the status quo (keeping the AAAS chemistry section unchanged and not creating a new national organization like ACS) as “very able and conservative document.” Clarke also wrote some veiled criticism of the ACS in that report: “[S]timulated apparently by its action [Clarke’s committee in the AAAS], the American Chemical Society has shown renewed activity. Hitherto,

²⁵⁸ American Chemical Society, New York Section. *Minutes of meetings of the American Chemical Society New York Section*. Vol. 1, March 5, 1897. Philadelphia, PA: Science History Institute, Othmer Library.

in spite of its claims to national standing, that society has been essentially a local organization, with headquarters in New York, and more than half its membership in or near that city.”²⁵⁹

Though from these sources it is difficult to ascertain exactly what the nature of the struggle was between the various factions within the ACS and the AAAS, there are some hints as to the nature of the conflict. First, there was clearly concern about which organization should take precedence. Frank Clarke was part of a Washington Association of Chemists that represented largely government workers. The ACS was a group in New York with some ties to chemical industries, and the AAAS was a national organization representing all scientists, more than just chemists. Even the initial *Proceedings of the ACS* (1876) reflected some hesitancy among members over the creation of a national chemical society. T. Egleston said that “it might be advisable to organize such an association some years hence; but at present, it was questionable if it could be successful.” H. Bolton gave similar arguments and added “there had always been, and there is now, a strong nucleus of chemists at the Academy of Sciences. ...It may be objected that the proposed Society is to be a national one. Even from this point of view it is unnecessary, as this want is provided for by the Chemical Section of the American Association for the Advancement of Science.”²⁶⁰ Even as late as 1889, the report by Albert Prescott in the *Proceedings of AAAS* – the same report Clarke had characterized as “very able and conservative” – suggested “On the question of the feasibility of the society as an organization of strength and credit the individual chemists consulted have been divided in opinion” and went on to summarize

²⁵⁹ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1890), 139-140.

²⁶⁰ American Chemical Society. *Proceedings of the American Chemical Society*. (New York: Trow's Printing and Bookbinding Company, 1876), 10-11.

many of the same arguments mentioned in the 1876 *ACS Proceedings*.²⁶¹ Thus in this case, the main tension was between different groups of chemists, many of whom are also associated with the AAAS but seek to obtain political power over chemistry.

Therefore, the divisions within the ACS were twofold. First, the attempt at creating a union of several associations caused political issues within the society. Second, also in the 1890s, there were disagreements about the role of disciplines such as Physics within the chemistry profession. One key difference between the ACS and Bache's efforts, however, was the leadership of ACS' emphasis on removing physics from their profession and separating it into some other group. At the same time, there seems to be tension over whether the various chemistry groups should ally to form a national organization. ACS, however, unlike its more general predecessor AAAS, was able to sustain an organization with many subdivisions and with more centralized authority over the profession of chemistry.²⁶² The question is whether there are factors that may have contributed to this unity of the chemistry profession.

Sharing Information

One very clear difference between ACS and AAAS is a concern among ACS' founders for the creation of journals and the sharing of information. The same concern does not seem to be true for the founders of the AAAS. The *Proceedings of the American Association for the Advancement of Science* was first published in 1848, the first year the AAAS existed. However, it was not published annually, with gaps of as many as three years, existing until 1914. Moreover, Alexander Dallas Bache, John Fries Frazer, and the central figures within AAAS do

²⁶¹ Frederick W. Putnam, ed., *Proceedings of the American Association for the Advancement of Science*. (Salem, MA: The Salem Press, 1889), 35-38.

²⁶² Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 80-85

not seem to be concerned with publication of the *Proceedings* or to pay much attention to publications within the AAAS. Rather, they seem to defer to Benjamin Silliman and his *Journal of American Science* as the principal publication for scientists within the U.S. The *Proceedings of the American Chemical Society* and *Journal of the American Chemical Society*, on the other hand not only start immediately upon the founding of the society but continued to be published consistently throughout the early years of the ACS.

Leaders of the American Chemical Society in fact seem to be extremely concerned about creating networks for exchange of publications, libraries that will provide access to chemistry journals, and in the creation of their own journal. As early as 1876, George Barker wrote to his colleagues asking for a formal system to foster the exchange of chemistry publications. This would include a network of chemistry associations (such as the New York Chemistry Club) and a list of chemistry journals (mostly from Europe); this network would then collect and publish lists of the journals they held (a kind of informal library system).²⁶³ Even more specifically, Barker wanted to ensure that this exchange of publications did not exclude *American Chemist*, a journal that ceased publication shortly after the creation of ACS' own journal.²⁶⁴ Barker was also strongly involved with the publications of the ACS. Again in 1876, Barker was concerned with the *Proceedings of the American Chemical Society* (that would later become the *Journal of the American Chemical Society* in 1879). I. Walz tells Barker that he was going to proceed "to the original plan" for the proceedings and was concerned that this new publication would make

²⁶³ I. Walz, "Letter to George Barker," May 2, 1876, Box 1, Folder 1 Item 3, George Barker Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

²⁶⁴ W. Entemen, "Letter to George Barker," August 15, 1876, Box 1, Folder 1 Item 9, George Barker Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

“a creditable appearance.”²⁶⁵ Barker was one of the more prominent leaders within ACS who was concerned with the information needs of the society.

George Barker, however, was not the only early leader concerned with the issue of information sharing. The New York Chemistry Club also established information sharing networks as a part of their mission. In the early 1870s, the club circulated a letter, “promoting the free exchange of information upon questions pertaining to chemistry.” The letter further suggested that it was the duty of the entire group to create an environment where information would be shared, “every member of the club can furnish information upon some branch of chemistry, no matter how apparently restricted the field or how remote its connection with chemistry”²⁶⁶ Thus, journals and information sharing seem to be a preoccupation among the leadership and some of the early groups of chemists that were forming and later creating the ACS. The question remains whether this information sharing and concern with communication may have contributed to ACS’ success in keeping its members together within the society. More importantly, does this concern for communication mark the beginnings of what would later become a more formal scholarly communication system?

²⁶⁵ I. Walz, “Letter to George Barker,” May 29, 1876, Box 1, Folder 1 Item 4, George Barker Papers, Philadelphia, PA: University of Pennsylvania Archives and Records Center.

²⁶⁶ Chemists Club, New York, NY. *Miscellaneous records of the Chemists' Club*. Box 37, Folder 1, Item 3, Philadelphia, PA: Science History Institute, Othmer Library.

Scientific Journals, 1818 – 1922

When examining the content between some of the most prominent American scientific publications, some very clear differences emerge, and it becomes possible to detect how these journals reflect the larger social context of nineteenth-century American science. The *American Journal of Science* (AJS) was published from 1818 and continues publication today. Through much of the early nineteenth century AJS served as a news source for American scientists; in the mid-nineteenth century AJS began to publish more original research in a variety of different fields, and by the twentieth century AJS is dedicated almost entirely to geology. The *Proceedings of the American Association for the Advancement of Science* (PAAAS) was published between 1848 and 1914 and overlaps with AJS. In the 1840s and 1850s, PAAAS is fairly similar to AJS, but with some key differences. PAAAS also serves as a news source, especially for news of the association, and by the twentieth century is almost entirely a directory of AAAS members; PAAAS also discusses theory and method of science somewhat more often than AJS. The *Journal of the American Chemical Society* (JACS) was first published in 1879 and continues publication. JACS combines elements of both AJS and PAAAS. Early in its publication, JACS publishes research, but it is not until the 1890s that JACS began to serve as a news source for the ACS and a space for discussion of theory and method in chemistry.

It is useful, therefore, to compare these journals in more detail. AJS and PAAAS were similar in scope but different in terms of who published them; Benjamin Silliman, a science professor at Yale, edited and managed AJS; AAAS, a scientific organization, disseminated PAAAS. Additionally, the two journals were different in terms of subject matter. PAAAS and JACS were similar in the sense that both were published by scholarly societies, and AAAS and ACS overlapped significantly in membership between 1848 and 1897. These two journals

differed significantly in their content, however, and by analyzing the content of these three journals, especially between 1818 and 1914 (the years that the two journals overlap), it may be possible both to see how these journals reflect the social dynamics with the organization of American science and to begin to understand if ACS' strategy of more tightly regulating publication did have an effect on the nascent scholarly communication ecosystem in the early twentieth century.

Performing a distant reading of over one hundred years of articles within three journals requires a combination of methods including computational topic modeling, comparison of word counts between journals, and statistical analysis of word frequencies. Topic modeling along with more in-depth textual analysis of words and concepts provides a good overview of the themes found within these journals, however. The combination of these methods can help to understand how these scientific publications reflect larger social trends in organization of science. By doing some textual analysis of both topics and some word-frequency lists in AJS, PAAAS, and JACS one can see how ideas of professional sciences shifted over the period of sixty years. AJS morphed from becoming a generalized science journal with some news content into a geology journal. JACS started as a specialized chemistry journal but later began to discuss more issues of method and theory. PAAAS has characteristics that are common to both of these two journals. PAAAS resembled AJS but also published more news content and discussion of theory. Since AAAS and ACS members overlapped and struggled for power among themselves for much of the 1870s through the 1890s, seeing how these journals compare can help to understand how dissemination of information became an important priority for leaders of the ACS.

A Brief History of Nineteenth-Century American Scientific Publishing

The historical context in which these journals formed - was, much like the history of scientific organizations, quite complex. Scientific journal publishing in the U.S. was not a very robust business during much of the nineteenth century. Between 1818 and 1876 AJS was edited by Benjamin Silliman and later by his son and son-in-law. AJS was the only consistently published science periodical during that time, and much of that journal's space was dedicated to news of the field rather than to original scholarship. Other journals such as *Science* tried to compete but tended to publish only for a few years before failing; *Science* eventually was revived by the AAAS in 1900. Some scientific institutions including the Franklin Institute and the American Philosophical Society also had their own journals that generally did not circulate beyond members of those institutions. Additionally, there were scientists who sought to replace AJS; most notably, George William Featherstonhaugh sought to rival AJS by merging multiple scientific journals published by local institutions like the Academy of Natural Sciences in Philadelphia and the Lyceum of Natural History in New York into one large journal. For many complicated reasons, Featherstonhaugh was also unsuccessful. Therefore, AJS was the main venue for publication, other than European journals, for most American scientists.²⁶⁷ AJS is still published today and now is "devoted to geology and related sciences and publishes articles from around the world presenting results of major research from all earth sciences."²⁶⁸

PAAAS was in many ways quite similar to *Science* or the other AJS rivals. PAAAS was not consistently published and was eventually replaced by the journal *Science*. PAAAS was also not a proceedings in the modern sense. Though much of the space within the pages of PAAAS

²⁶⁷ Simon Baatz, "Squinting at Silliman: Scientific periodicals in the early American republic, 1810-1833." *Isis*, 82, no. 2 (1991): 223-244.

²⁶⁸ "About," *American Journal of Science*, August 28, 2018, <http://www.ajsonline.org/site/misc/about.xhtml>.

was dedicated to papers presented at conferences, there were also original articles submitted from scientists around the United States, often in form of letters written to editors (AJS often published similar letters). There were also news items from the field, lists of members and prominent scientists, and accounts of scientific meetings around the world. In all, PAAAS was quite similar in the scope of its content to AJS. The only major difference between PAAAS and AJS was the fact that PAAAS was officially published by AAAS whereas AJS was published by the Silliman family and was often referred to as “Silliman’s Journal.” Additionally, PAAAS, before ceasing publication in 1914 dedicated more and more space to disseminating names and addresses of members of the organization. Though listing members had always been a part of PAAAS’ content, by the twentieth century there was not much discussion of scientific research and by 1911 PAAAS was little more than a directory of members. In the final issue of 1911, only 61 (out of 385) pages are dedicated to society business, and the rest of the issue contains names of members of AAAS.

JACS was first published as the *Proceedings of the American Chemical Society* from 1876 until 1879 and then changed its title in 1879. JACS was both the first consistently published specialized scientific journal in the U.S. and the first such journal to be sponsored by a scientific society in the U.S.²⁶⁹ The content of JACS, is also similar to both AJS and PAAAS. JACS contained news of the field and some original scholarship. Unlike AJS and PAAAS however, JACS dedicated more space to accounts of experiments. For instance in the first year of the journal in 1879 just under 60 pages out of over 600 are dedicated to business of the society; the rest relate to chemical experiments. As early as 1879, JACS resembles a more contemporary scientific journal with research articles than either AJS or PAAAS did when they first began.

²⁶⁹ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*, 296 - 297.

Like AJS, JACS also still publishes today. There are many more specialized journals in chemistry that are also published by the ACS and were formed out of JACS. JACS is presently, according to ACS, “the world’s foremost journal in all of chemistry and interfacing areas of science.”²⁷⁰

Methodology for Analysis of Journals

To perform an effective distant reading of these three journals (AJS, PAAAS, and JACS), there were several steps. All three of these journals, fortunately, have large amounts of content that fall within the public domain (i.e. were published prior to 1923) and that have been digitized in online collections such as the HathiTrust Digital Library (<https://www.hathitrust.org/>). Therefore, after obtaining electronic copies of individual years of the journal, it was necessary to create full text (not just images or pdfs) so that Mallet (the topic modeling program used for this dissertation) could create outputs for analysis. Overall, these three journals combined contain 209 text files (one text file for every year the journal published until 1922) and about seventy-three million words. These text files contain the entirety of the dataset used for this dissertation. Two topic modeling analyses were run on this dataset. First, an initial topic model of forty topics utilizing Mallet was performed on each of the 209 text files (or years) and compared between the journals, these topic models were then categorized and visualized in spreadsheets so that it was possible to create visualizations for each of the three journals and to compare those visualizations to see how the three journals differed and how they changed over time (see Appendices I through VIII). After performing this analysis, a second topic model was run on the entire corpus. For this topic model, each of the 209 text files were split into documents of 1,000 words and a 500 topic

²⁷⁰ “About,” *Journal of the American Chemical Society* August 28, 2018, <https://www.pubs.acs.org/page/jacsat/about.html>.

model was created to investigate the corpus as a whole (see Appendix IX for the topic model and Appendix X for a visualization of the categories within that topic model).

Both methods utilized for this dissertation overlap with the methods used by scholars such as Emily Marshall. In Marshall's analysis of British and French newspapers to understand demographic trends, she performs topic modeling and then topics or categories that, "were chosen to best summarize a topic" were selected by consulting relevant articles and by using "top words" that best represented the topic's substantive meaning.²⁷¹ Similar methods of identifying categories of topic models from current literature or previous scholarship have been utilized in more than just historical studies like Marshall's in fields such as psychology.²⁷² Similar methods of topic modeling a corpus and further refining categories for analysis have also been used in other historical studies.²⁷³ Based upon the methods used for all of these studies, the topics generated by Mallet in the topic models used for this study were also further refined utilizing the work of previous historical scholarship including Simon Baatz on the history of the AJS²⁷⁴ and Browne and Weeks on the history of the ACS in order to create meaningful categories based on the types of research these scholars have identified in journals such as AJS, PAAAS, and JACS.²⁷⁵ Since there is no history of the PAAAS, Baatz's work was used for both PAAAS and AJS since the journals overlap significantly in both publication period and subject matter.

²⁷¹ Emily Marshall, "Defining population problems," 712.

²⁷² André Bittermann, "How to identify hot topics in psychology using topic modeling." *Zeitschrift für Psychologie*, 226, no. 1 (2018): 3–13.

²⁷³ Gregoire Croidieu and Phillip H. Kim, "Labor of Love: Amateurs and Lay-expertise Legitimation in the Early U.S. Radio Field," *Administrative Science Quarterly*, 63, no. 1: 1–42.

²⁷⁴ Simon Baatz, "Squinting at Silliman: Scientific periodicals in the early American republic, 1810-1833." *Isis*, 82, no. 2 (1991): 223-244.

²⁷⁵ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*.

AJS and PAAAS were more directly comparable. Both of these publications produced generalized scholarship and were not specialized. Therefore, the topic models from Mallet often mapped to disciplines such as geology or chemistry. It was more difficult to compare JACS directly to AJS or PAAAS. JACS was a specialized journal for chemistry. Therefore, unsurprisingly, most of the topics were about chemistry experiments. All three of these journals, however, contained topics about business of the association, theory, and method, and these topics were quite distinct from either the disciplinary topics in AJS or PAAAS or the chemistry topics contained in JACS. Therefore, it was possible to compare the number of topics dedicated to business, theory, and method between all three journals.

AJS was the largest of three datasets with 104 text files and just under forty-one million words. There were two archives (Carnegie Mellon's digital collections - <https://digitalcollections.library.cmu.edu/portal/browse.jsp> and the HathiTrust - <http://hathitrust.org/>) containing the entirety of this journal. Between these two collections, it was possible to obtain images that could be used for Optical Character Recognition (OCR). With the OCR one could generate the full-text of all articles published in AJS during this hundred-year period. Altogether, the corpus contains roughly 100,000 pages and over 4,000,000 words. Because the structure of the journal was so inconsistent it was not possible to separate out individual articles using computational methods. It was not until the late 1880s that the journal began to use consistent running headers and other information that could be used to identify individual articles. Moreover, during the early years of the journal, it was quite common to print letters to the editor or conference proceedings that were then published in one long narrative called "Intelligence" which endeavored to give news about the scientific community in the United States. Therefore, the journal was analyzed by year rather than by article.

OCR was performed on two of the three journals (AJS and PAAAS) utilizing ABBYY Fine Reader version 14. For JACS, OCR was obtained through the HathiTrust Digital Library. For JACS, HathiTrust had versions of all of the issues between 1879 and 1922 and HathiTrust also contained digital versions for AJS and PAAAS. However, for AJS, much higher digital quality versions were available through the Digital Collections of Carnegie Mellon University. Obtaining higher quality versions of these early journals was especially important since the quality of printing was poorer in the United States during the nineteenth century; therefore, the digitized images available through HathiTrust, where black and white images contain noise and multiple other imperfections, might cause ABBYY to misread characters. The Carnegie Mellon Collection of digitized materials only goes up to 1895, but by that time the quality of printing had improved, and it was possible to find higher quality images within HathiTrust that could then be read by ABBYY. For PAAAS, the highest possible quality images were selected among multiple versions of the journal within HathiTrust and ABBYY was again used for the OCR.

The quality of OCR varied significantly between journals and between years. For example, in AJS, a random sample 1,000-character of words from an issue of the journal in 1819 had 78 errors, or an accuracy rate of 93.92%. Yet, in 1919, the OCR rates were significantly better, a similar sample in 1919 contained 6 errors in 1,000 characters, or a rate of 99.94% accuracy. This difference is largely due to the better quality of printing in the journal over the course of one hundred years. For JACS, utilizing 10 samples (one from 1879, 1884, 1888, 1893, 1898, 1903, 1908, 1913, and 1918) of 1,000 characters, there was an average rate of 12 errors per 1,000 characters, or 98.98% accuracy, and these averages varied largely based on the quality of scans from individual issues. PAAAS had similar rates of OCR accuracy to JACS. Utilizing 10 samples of 1,000 characters (one from 1848, 1853, 1858, 1863, 1868, 1873, 1878, 1883, 1888,

and 1893), there was an average of 16 errors per 1,000 characters, or 98.94%. While the accuracy of the OCR varies over time, generally improving in later years, in all samples the accuracy rate was above 90% and so considered sufficient for this general study of the journals' contents.

After obtaining the OCR of the individual years, there were two potential topic modeling tools. Topic modeling analyzes words utilizing a Latent Dirichlet Allocation (LDA) model. LDA determines the statistical likelihood that individual words are related to each other, thus providing researchers with a "distant reading" method for analyzing large amounts of text.²⁷⁶ One topic modeling tool, available at Indiana University, is the Indiana Philosophy Ontology project, or InPHO (<http://inphodata.cogs.indiana.edu/>). Another tool, more commonly known, is called Mallet (<http://mallet.cs.umass.edu/topics.php>). Ultimately, Mallet was utilized because it is more widely adopted within the textual analysis community. In order to frame the analysis of AJS, Simon Baatz's article "Squinting at Silliman" was valuable as a guide for creating categories of content.²⁷⁷ Baatz discusses some of the historical developments with the journal as well as some of the larger social issues that Benjamin Silliman faced when he was managing the journal.

Mallet returns a list of words that have a statistical probability of being related to each other. These words are called topics. Additionally Mallet provides other information such as distributions of words among topics. It is up to individual researchers to determine the meaning of the "topic" to which these words relate.²⁷⁸ For instance, one of the topics Mallet returned for

²⁷⁶ Franco Moretti, *Distant Reading*. London: Verso, 2013.

²⁷⁷ Simon Baatz, "Squinting at Silliman," 223-244.

²⁷⁸ Elijah Meeks and Scott B. Weingart, "The Digital Humanities Contribution to Topic Modeling," *Journal of Digital Humanities* 2, no. 1 (Winter 2012): <http://journalofdigitalhumanities.org/2-1/dh-contribution-to-topic-modeling/>.

AJS in 1819 contained a list of words including: country, Ohio, prairies, lake, ground land, soil, hills, grass, and waters. This is a topic referring to the geographical surveys sponsored by the U.S. government during the early nineteenth century. Other topics might include words like slate, quartz, and strata that are clearly related to geology. One of the important tests for this topic analysis of AJS was to determine whether it was possible to detect topics about News. According to Baatz, news about the field was one of the primary purposes of the journal in the nineteenth century and one of its most prominent genres.²⁷⁹ Do the topic models demonstrate the same trend?

Since topics could often be quite specific, it was necessary to group together some topics into more general categories. To obtain these content categories, topic models were created for every year individually and each topic model created a list of 40 topics (or lists of related keywords) for each year. It would also be possible to create a topic model over the entire corpus and generate separate files for each year of each journal. I chose a more labor-intensive method, however for two reasons. First, I wanted to create a dataset that would generate very specific topics for individual years. With such a dataset, it may be possible to detect influence of individual figures such as Alexander Dallas Bache on the science of particular years when his Coastal Survey was funding research. Second, I hope to be able to do more with this dataset in time and having word distributions and other information Mallet provides for individual years may be useful.

These topics were assigned to 17 categories. These categories included disciplines such as astronomy or chemistry, genres of articles such as geographical and coastal surveys, and

²⁷⁹ Simon Baatz, "Squinting at Silliman," 223.

broader discussions on issues such as publishing, theory, and news. There is also an “other” category. This category represents several different kinds of topics. Some of the topics in the “other” category appear infrequently such as music articles that appear early in the journal’s run. This category also contains topics that could not accurately be identified, perhaps representing an amalgamation of scientific concepts that do not fit as neatly into modern scientific disciplinary categories. The intention in topic modeling every year individually rather than modeling the corpus as a whole was to create a dataset that represented very specific topics on a year-by-year basis. The initial categories for the *American Journal of Science* included:

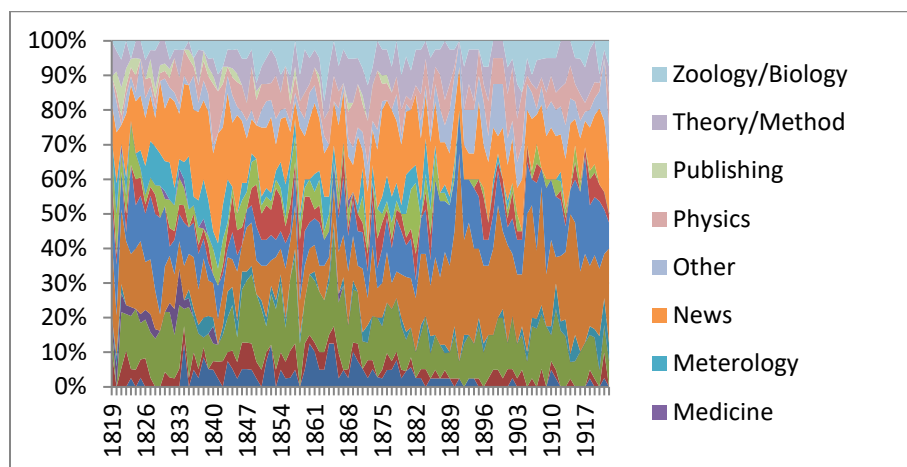
1. Astronomy
2. Botany
3. Chemistry
4. Engineering
5. Fossils
6. Geology/Mineralogy
7. Geography/Survey
8. Geography/Coastal
9. Mathematics
10. Medicine
11. Meteorology
12. News
13. Other
14. Physics
15. Publishing
16. Theory/Method
17. Zoology/Biology

After creating these categories, the number of times each category appeared during a given year was counted and placed into a spreadsheet showing how many times each category appeared in all of the years for the journal. Additionally, the percentages of each of these categories against the total number of categories were calculated. For example, the category of mineralogy appears 9 times in 1819 and 24 times in 1891. Mineralogy represented 22.5% of all topics in 1819 and 60% of all topics in 1891. These basic mathematical summaries provided the

ability to create visualizations of the topics and to show how the frequency of topics changed over the 100-year time span (see Figure 1, a larger version is also in Appendix I). Since this first visualization is so complicated, a more basic visualization was created by combining the topics of Fossils, Geology/Mineralogy, Geography/Survey, and Geography/Coastal into a single “Geology” category. News and publishing were also merged into a single category of “news.” Finally, all of the other disciplines were combined into the “other sciences” category. Chemistry, physics, and theory/method remained as a single category. Additionally, categories were grouped into spans of 25 years, to allow for a smoother representation of change over time. These changes allowed for clearer visualizations of the dataset (see Figure 4).

Figure 1

**Visualization of the percentage of all categories in the American Journal of Science
1819 - 1922**



The PAAAS is the smallest of the three journal datasets containing sixty-one text files each representing one year and just over ten million words. For the PAAAS, exactly the same method was utilized as for AJS with two key differences. First, electronic copies of PAAAS were only available in the HathiTrust database; therefore, rather than utilizing two different

electronic archives, HathiTrust is the sole source for this dataset. Second, during the data analysis it became clear that many of the topics were discussing the business of the society. At times these topics also contained news items about individual members of the AAAS. Rather than trying to separate out news and other business, however, these two categories were combined as one “Business” category.

From the topic models, it also appears that the theory and method topic is significantly larger within PAAAS than it was within AJS. In order to test whether this apparent difference within the topic models is actually significant, another dataset (n=54) was created of words such as *theory*, *method*, *fact*, and *evidence* that could indicate discussion of theoretical and methodological topics. This list of words was then compared to the total number of words within PAAAS and AJS during the period when these two journals overlapped (1848 – 1914). This comparison provided a sense of proportion about how often these two journals were using theory-related words in relation to all of the words being used in the journal during that time period.

JACS, the last of the three journals analyzed for this dataset, contained forty-four files and about twenty-two million words. A similar technique (topic modeling with Mallet) was used, though because the data were different, the topics were categorized differently. A dataset of optical character recognition (OCR) text from all of the issues of JACS between 1879 and 1922 (the last year in the public domain) was created and was downloaded again from the HathiTrust repository (<https://www.hathitrust.org/>). After performing the LDA topic modeling and creating a topic list of twenty topics for each year of JACS between 1879 and 1922, a historical analysis using Browne and Weeks history of the American Chemical Society, was employed to organize the data; this volume is still the most comprehensive account of the history of the American

Chemical Society for the early period (1879-1922) of the society.²⁸⁰ Browne and Weeks' history also contains a history of JACS and an analysis of the topics contained within the journal.

Topics produced by Mallet were organized into "expected" topics, or topics that were mentioned in Browne and Weeks, and "unexpected" topics, or topics that were not discussed within Browne and Weeks' discussion of JACS. Expected topics are largely related to chemical experiments.

Unexpected topics usually contain words like "*president, election, or committee*" and often refer to the business of the society, methodology of chemistry, or other professional issues.

After the initial analysis to determine whether there were any major differences between these two groups (expected and unexpected) topics, a second dataset of unique words from the unexpected topics was created; this dataset (n=74) represented unique words from several subgroups of unexpected topics including topics about the business of the society, topics about methodology, and other miscellaneous issues. A word frequency analysis was run on these words to determine the number of times these words appeared for every year between 1870 and 1922. Finally, a dependent sample t-test was run on these word counts to determine whether there was a significant difference between the mean of the word frequencies.

American Journal of Science (AJS), 1818 – 1922

AJS provides a good foundation for investigating how scientists in the nineteenth century used journals. It is the only journal that consistently published throughout the nineteenth century, and it was a journal recognizable to all American scientists. Topics within AJS reflect changes in science in the United States over a period of one-hundred years. Over the history of AJS, certain disciplines fluctuate over time, and finally and some topics such as business, theory,

²⁸⁰ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*.

and method that were less prominent within AJS, and PAAAS often discussed these more general concerns of science. Second, for many years, chemistry was an important topic within AJS, but after JACS provided a more specialized forum for chemistry research, the topic slowly declined in both AJS and PAAAS throughout the twentieth century.

Benjamin Silliman, in his very first preface to AJS stated that the journal, “will be a leading object to illustrate American Natural History, and especially our Mineralogy and Geology. The applications of these sciences are obviously as numerous as physical arts and physical wants; for not one of these arts or wants can be named which is not connected with them.”²⁸¹ Based on the chart in Figure 2 (see also Appendix II), Silliman’s goal appears to have been realized. When one looks at the number of topics about individual disciplines, that is, how many topics from the topic model are related to disciplines such as geology or chemistry, topics discussing geology are the most dominant topic over time, representing roughly 35% of topics between 1819 and 1922. Interestingly, however, the “other sciences” are also represented equally at 35%. Yet, none of the subtopics within “other sciences” dominates. Astronomy, Botany, Engineering, Medicine, Meteorology, Physics, and Zoology, individually each represent less than 10% of whole. In any given year, none of these topics represent more than 13%, physics being the only exception which represents 17.5% of topics in 1840. Chemistry is one major exception. As a discipline, it represents 13% of the total topics over this one-hundred-year period, and, in individual years within the period, often represents 20% - 25% of topics.

²⁸¹ Benjamin Silliman, “The Plan of the Work,” *American Journal of Science*, 1, no. 1 (1818), v.

Figure 2

**Percentage of Topics in the *American Journal of Science*
All years 1819 – 1922**

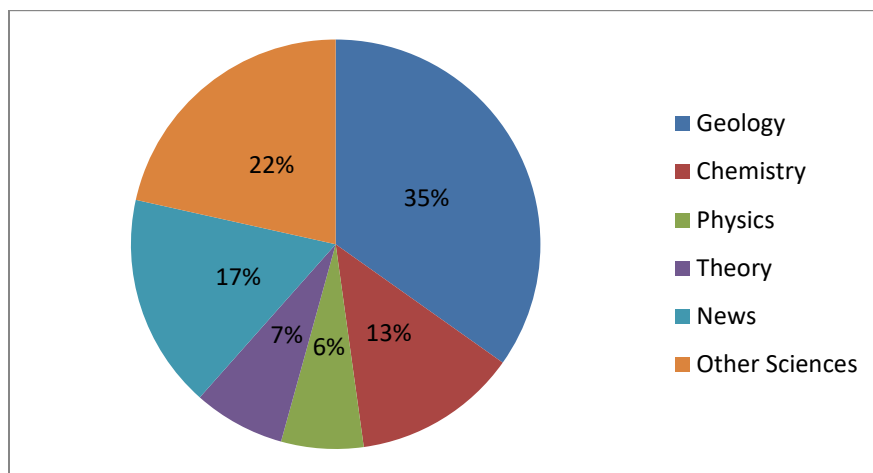


Figure 2 also demonstrates Simon Baatz's point that news was an important topic throughout this period.²⁸² Topics related to news represent 17% of total topics, and often represent 20% of topics for individual years. Every issue had a section called *Intelligence* that was dedicated to news from the field. Additionally, individual articles, particularly in the earlier years of the journal, would be dedicated to translating and commenting upon articles published abroad and also on publishing letters to the editor that would discuss scientific endeavors both in the U.S. and abroad. The emphasis on news – largely the communication of scientific research in the U.S. and abroad – revealed by distant reading of the actual articles within the AJS supports the arguments that Baatz and others have made about the importance of AJS in the history of scientific communication within the U.S.

²⁸² Simon Baatz. "Squinting at Silliman," 223.

The topic models also demonstrate some interesting, though not particularly surprising, trends. Figure 3 (see also Appendix III for larger version), a simple line graph showing the number of topics within categories, shows that geology topics increase over time, whereas other topics generally decrease. The graph also shows that until about 1871, “other sciences” were significantly higher than geology. Also, in 1871 “other sciences” decline precipitously and geological topics increase and overtake “other sciences.” Since AJS is currently a journal dedicated to geology, one would expect to see this trend. It is interesting to note, however, that this shift happens in the period from 1871 to 1897. The 1890s are a period when multiple other scientific professional societies are created, along with related scholarly journals. For instance, JACS was founded in 1879 and the *American Physical Review* (journal for the American Physical Society, the society for physicists) began in 1893. The trend line for chemistry topics also shows a decline during this period. Overall, the trends illustrated in Figure 3 may be evidence of scientists leaving the more generalized AJS for more specialized journals when they are created. The decline of “other sciences” coincides with the period during which the more specialized journals were established.

Figure 3

**Trends in number of topics in the *American Journal of Science*
1819 – 1922**

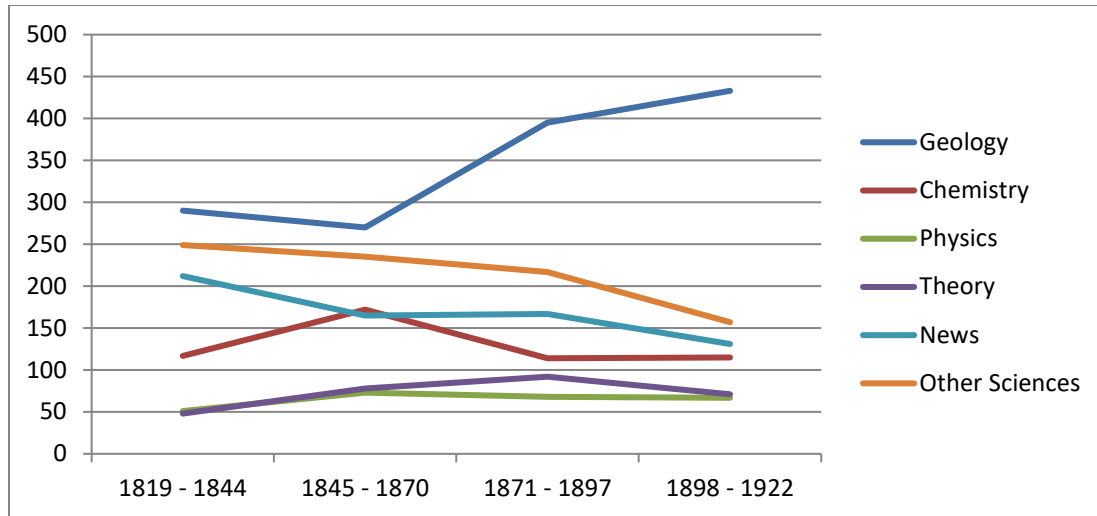
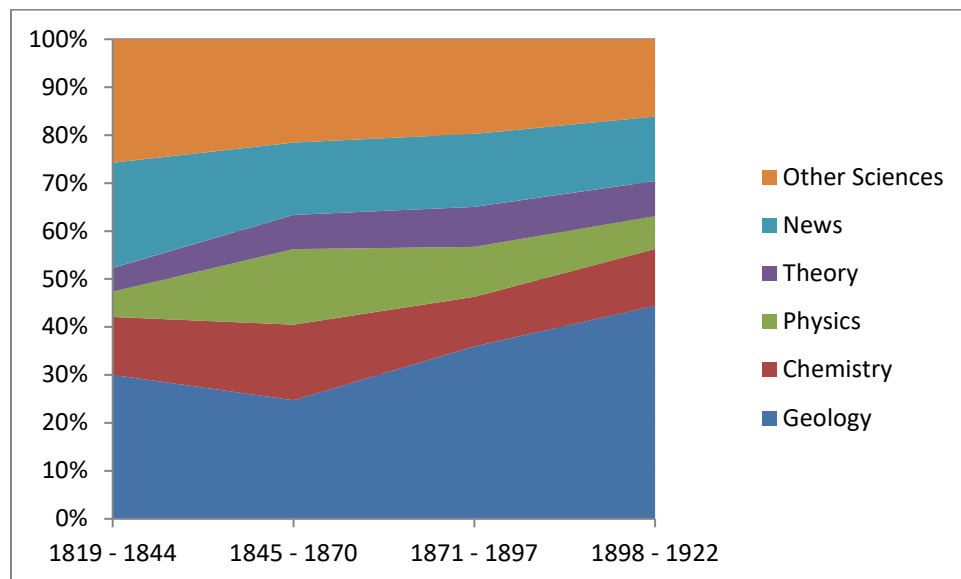


Figure 4 (larger version in Appendix IV) shows much the same data as Figure 3; however, it represents the topics as a percentage of the whole, rather than as raw numbers of topics as shown in Figure 3. This graph presents some nuance to the picture presented in Figure 3. Geology topics represent fewer than 30% of the entire number of topics in 1819, and that number gradually increases to nearly 40% in 1922. Conversely, other sciences represent a high of nearly 60% in 1845 but decrease to a low of about 35% in 1922. Thus, one can see that other sciences are still an important number of topics even as late as 1922. This could complicate the story about scientists departing to other journals. It is possible that many scientists, despite the appearance of alternative journals, are still choosing to publish in AJS. Additionally, this relatively high percentage of “other science” topics could simply demonstrate that geology is a

discipline that requires knowledge of other disciplines such as physics or biology in order to perform geological work.

Figure 4

Topics represented as a percentage of the whole in the *American Journal of Science* 1819 – 1922



Proceedings of the American Association for the Advancement of Science (PAAAS), 1848 – 1915

PAAAS is an interesting journal to compare with AJS. The two publications both circulated during the later half of the nineteenth century, and PAAAS covered the same general topics as AJS. Nonetheless, there were significant differences between the two journals. Figure 5 (also available in Appendix V) shows the percentage of all topics in PAAAS between 1846 and 1914 and serves as a useful counterpoint to Figure 2 (showing percentage of all topics for AJS). There are some very clear differences between the two journals. Geology is still an important

topic but only represents 17% of all topics, as opposed to 35% for AJS. PAAAS also contains a new topic, business of the society that clearly dominates all other categories at 35%. In Figure 6 (see also Appendix VI), the dominance of business becomes even more apparent, and one can see that a few years before PAAAS ceased publication, the journal was entirely dedicated to the business of the society. The dominance of this business topic is not particularly surprising since PAAAS was the official publication of AAAS, and one would expect a fair amount of the publication to be dedicated to business news about the society. Other sciences (such as astronomy, botany, and biology) are also slightly less represented than they seem to be in AJS, but not significantly so. Interestingly, chemistry seems to be better represented in AJS at 13% rather than 5% and Physics only 6% in AJS rather than 7% in PAAAS of total topics.

Figure 5

**Percentage of Topics in the *Proceedings of the American Association for the Advancement of Science*
All years 1848 – 1914**

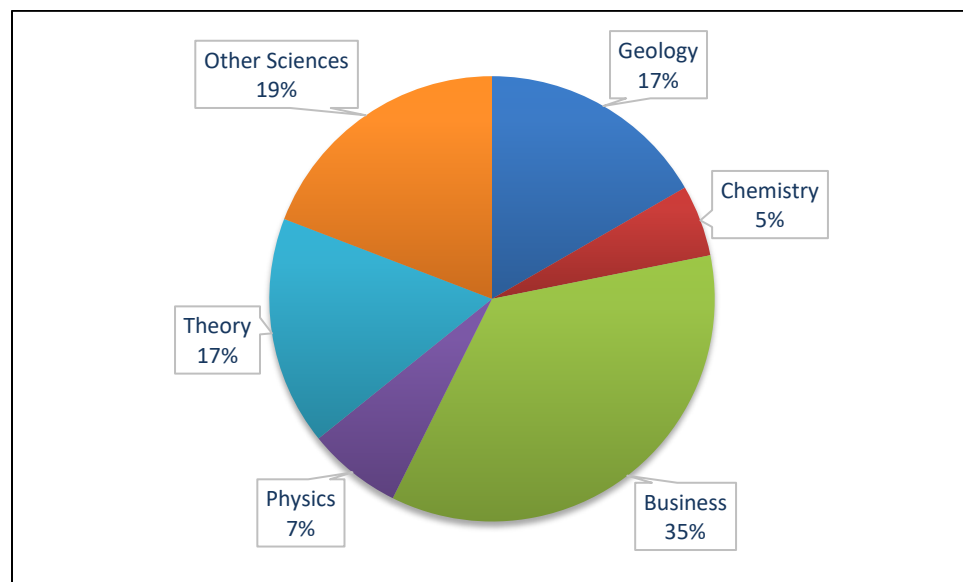
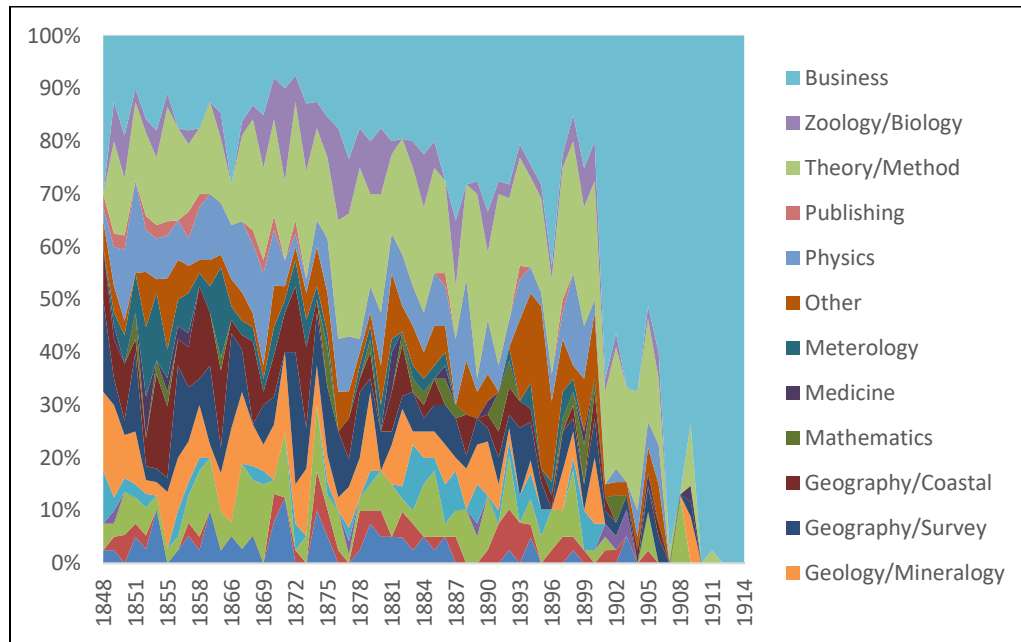


Figure 6

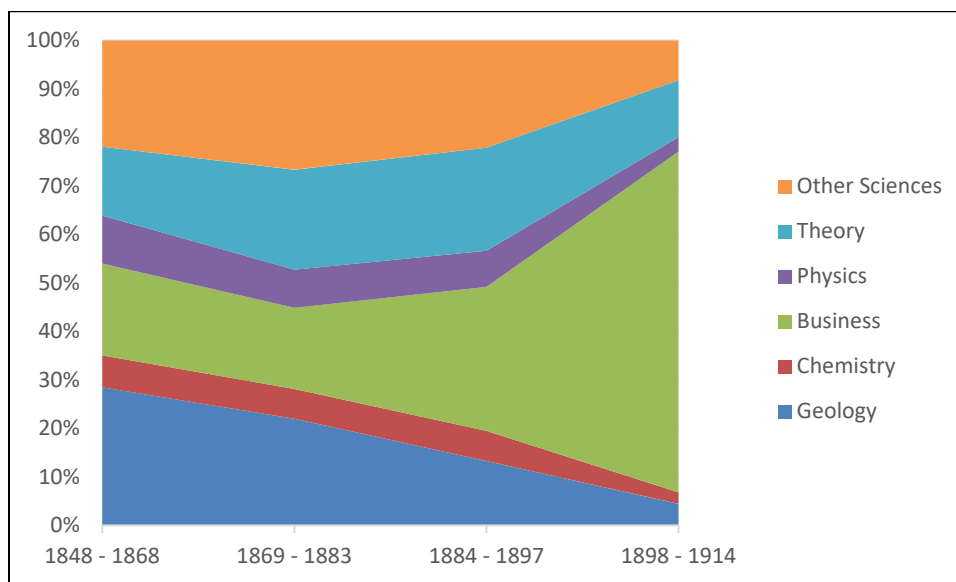
**Percentage of all categories in the *Proceedings of the American Association for the Advancement of Science*
1848 – 1914**



What is particularly interesting in these topic models, however, is the amount of theory and method within PAAAS. In AJS, theory represents 7% of all topics. In PAAAS that percentage more than doubles to 17%. Figure 7, showing the percentage of topics over time (comparable to Figure 4 for AJS) illustrates PAAAS' publication of theory more clearly. Within AJS, theory usually represents less than 10% of topics in any given year, and at most represents 17% of topics in a few years. Within PAAAS theory is never less than 10% and often represents more than 20% of topics within particular years.

Figure 7

**Topics represented as a percentage of the whole in the *Proceedings of the American Association for the Advancement of Science*
1848 – 1914**



This increase in theoretical and methodological topics may, however, be an artifact of the topic modeling rather than an actual statistical difference. In comparing the dataset of theoretical words, it does appear that theoretical and methodological word use is slightly higher in PAAAS than in AJS, but not significantly so. When comparing all of the words in the sample ($n=54$), theoretical words represent 0.8% of all words used within AJS between 1848 and 1914. Within PAAAS theoretical words represent 1% of total word usage. Individual words like *theory* and *method* are similar. Theory represents 0.04% of word usage within both AJS and PAAAS; Method represents 0.05% in AJS and 0.04% in PAAAS. Rarely do these words ever represent even 1% of the entire corpus and generally all of the words within this sample are used about the same amount of time in both AJS and PAAAS. Therefore, the topic model is reflecting some increase in discussion of theory that does not appear to be present in the proportion of theoretical words used within these two corpora.

Overall, the distribution of topics within AJS and PAAAS are similar. Both journals represent about the same amount of chemistry and physics, and both journals have about the same proportion of other sciences like botany and astronomy represented. PAAAS and AJS also illustrate Baatz's argument that American scientific journals in the nineteenth century were an important news source for scholars scattered throughout universities in the U.S. In the case of PAAAS, its purpose as a news source is much more pronounced and business of the society represents a very large proportion of topics throughout PAAAS' publication. What is most interesting with PAAAS and what makes it different from AJS is its proportion of topics related to theory.

In part, PAAAS' discussion of theory and method could be a product of PAAAS' overall mission as a source for news about the society. Many of the articles within the theory topics contain speeches by presidents and officers of AAAS discussing why science is important to the U.S. and how science has progressed over a period of time (usually during their tenure as president). There are, however, some articles that are particularly dedicated to method and how American science should differentiate itself from other approaches to science common in Europe. Thus, it seems that PAAAS may have in part been filling a need to distribute articles about larger issues within science that was not being met within AJS. Discussion of news and business about the society also became an important discussion topic within JACS during the 1890s.

Journal of the American Chemical Society (JACS), 1876 – 1922

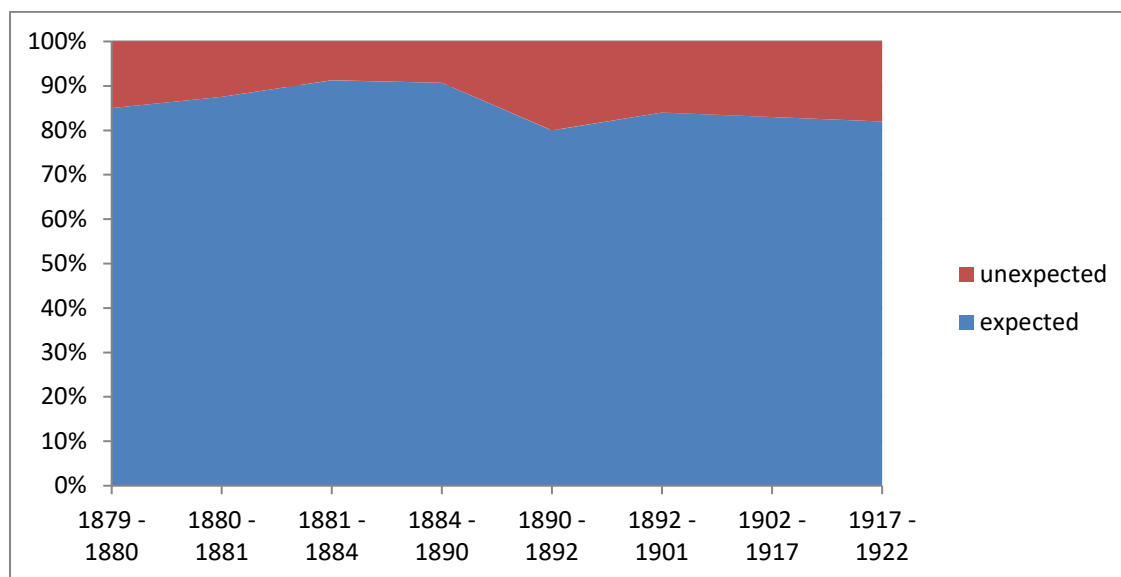
As one would expect JACS was a journal that primarily published results of chemistry articles, and the vast number of topics within JACS are about chemistry. Therefore, rather than

examining the types of topics being discussed in chemistry, it is more useful to examine how chemists in JACS were discussing topics of professionalization. Articles about professional issues usually show up in topics discussing either the business of the society or in articles about disciplinary theory. Using Browne and Weeks' history of ACS, specifically their discussion of chemical topics discussed in the journal (discussed here as "expected" topics) and comparing those expected topics to the "unexpected" topics that Browne and Weeks do not discuss, some interesting patterns emerge.²⁸³ The initial comparison between unexpected and expected topics showed that unexpected topics, shown in Figure 8 (and also in Appendix VIII), were consistently a small number of topics in any given year (less than 20% of all topics). Nonetheless, the unexpected topics doubled during the tenure of one particular editor in the years 1890 – 1892, from 10% to 20% of topics, and that increase stayed consistent until the end of the dataset in 1922. This raises the question of whether this seemingly significant change in unexpected topics is actually suggesting an important variation in the content of the journal or is simply an artifact of the LDA topic modeling.

²⁸³ Charles Albert Browne Mary Elvira Weeks, *A History of the American Chemical Society*.

Figure 8

**Distribution of Expected and Unexpected Topics grouped by editorial years - *Journal of the American Chemical Society*
1819 – 1922**



To determine whether the change in topics during this period was indeed significant a smaller dataset of keywords found in these topics was constructed to see if there was a significant difference in the word frequencies before 1890 and after 1892. To control for the vast increase in the size of the journal (especially at end of the dataset) the word frequencies (see Appendix XI for the full list of words) were created for eleven-year periods pre-increase (1879-1891) and post-increase (1892-1903). Looking at the rate of increase for these words, the results show similar trends to the topic model. Overall, the words related to “unexpected” topics appear 25 times per 1000 words during the first eleven years of the journal, and during the next eleven years, the same word list appears 27 times per 1000 words. This increase is perhaps not as dramatic as the topic model graph would suggest, but it is still an increase. Looking at more

specific words, “method” appeared 1.75 times per 1000 words 2 times per thousand in the 1879-1891 period, indicating an increasing interest in how chemists arrive at their results. “Results” also showed a significant increase from 1.28 to 2 during these two periods. As a point of comparison, the word “chemistry” stayed constant appearing 0.9 times per 1000 words in both time periods. The most significant increase in rate is “work” which appeared only 0.3 times per 1000 words prior to 1892 but increased to 1.1 in the next ten-year span of time. Other words appeared much less frequently, but still show an increase. “Theory” grew from 0.16 times per 1000 words in the pre-1892 period to 0.27 after 1892; “research” rose from 0.06 to 0.26, “book” from 0.01 to 0.3, and “review” from 0.06 to 0.3. These increases in words related “unexpected” topics further support the topic models by demonstrating that at least with certain keywords there was an increase during this important period of ACS and JACS history.

This increase in discussion of business and professional issues is especially important because it occurs at the very time, the mid-1890s, that the ACS becomes a unified association comprising AAAS’ section on chemistry and was therefore separate from AAAS. Chemistry decreases as a topic both within AJS and PAAAS during this time period, perhaps indicating that chemists were moving from the more generalized scientific journals into their own more specialized outlet for discussion of chemistry-related topics. Additionally, AJS and PAAAS were both sources of news about science more generally. If chemists were already migrating to JACS because of the more specialized content and had less ability to talk about general news of the profession since they were officially no longer a part of AAAS after 1897, it would make sense that chemists at the time who wished to discuss professional issues would have to find another venue. JACS seems to become this venue and the topic models provide further evidence of the shifting of the chemistry profession from publications such as AJS and PAAAS.

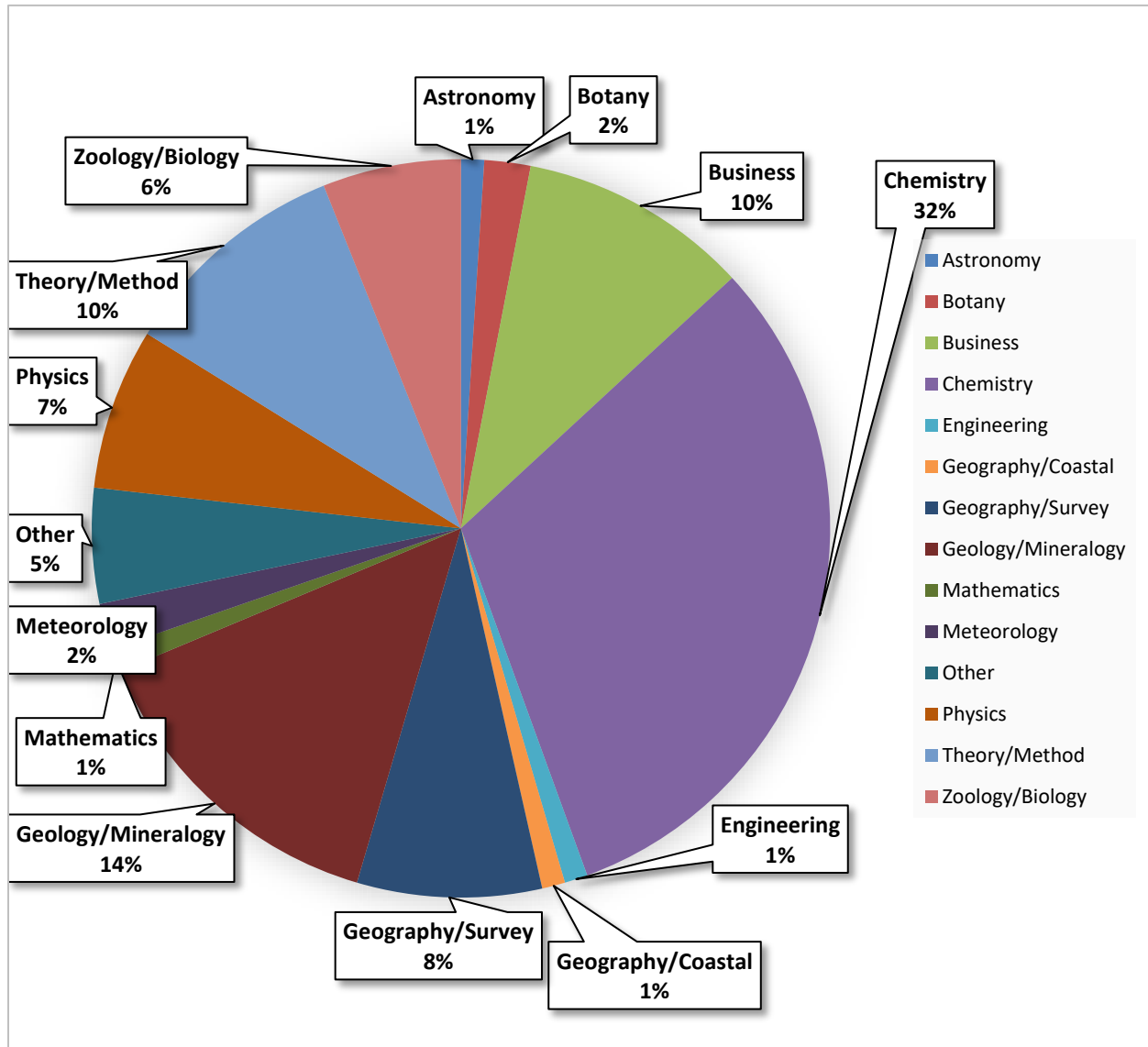
Furthermore, because leaders within the ACS had long stressed the journal as an essential component of their professional strategy, and because JACS had always published about professional issues and theory (even before 1890 these topics represent about 10% of overall topics), this shift in topical discussion of theory, method, and business within JACS helps to support the argument that these leaders' focus on the journal as a way to unify their professional identity may have been successful.

Topic Model of the Full Corpus (AJS, PAAAS, and JACS), 1818 – 1922

When one looks at the corpus of all three journals as a whole, the same general trends can be found in the data. Figure 9 (see also Appendix XI) shows the overall composition of topic categories (the same categories used for the AJS and PAAAS comparisons). Unsurprisingly, chemistry comprises 32% of the topics; this is most likely because JACS is such a large part of the dataset. Similarly, geology and mineralogy are the next most significant number of topics at 14%, representing much of the subject matter of AJS. Additionally, some subject areas such as zoology, botany, and meteorology are more prominent in this topic model than in the other models. There are two areas, however, that are of particular relevance to this investigation: theory and method and business. Both of these categories might help to indicate trends in professionalization. Given the trends from the previous analyses, it is important to ask in which these theoretical and business topics appear and during what time period. Presumably, if the previous analyses were correct, then the answers would be that theoretical topics are more prominent in PAAAS and that both of these topics should increase during the late 1870s.

Figure 9

Visualization of Categories for Topic Model of All Journals Utilizing Documents of 1,000 Words, 1818 – 1922



One topic that typifies the kind of topic for theory and method is topic 16 (term terms general called case true present sense relations defined definition relation form definite considered question paper applied expressed conditions); this is a topic with general words about

science and how it is performed. For this topic, the largest number of words assigned to that topic (45) comes from PAAAS in 1876. A similar topic is 208 (factor influence conditions factors important direct effect relative relation determining control role present combined importance influences indirect data favorable normal) where the top related documents also come from PAAAS in the 1890s. Thus it seems that as with the previous topic model analysis, PAAAS discusses more theoretical topics, and these topics cluster during the later part of the nineteenth century.

With regard to business topics, especially as they pertain to the ACS, topic 114 (society chemical american journal chemistry chemists members editor year abstracts papers industrial meeting council address york number publication proceedings directors) is a topic discussing meetings of ACS, and also addresses their publication concerns. This topic appears only in the JACS documents, and the earliest date in which this topic appears is 1893, around the same time as the “unexpected” and “expected” topic divide happens from the previous analysis of JACS. Topic 311 (committee report secretary congress appointed international members council meeting year association account library fund chairman treasurer adopted committees received society) a more general topic also referring to meetings, appears most frequently in PAAAS. The earliest PAAAS issue for this topic is 1874, and most of the documents assigned to this topic come from the 1890s which would again be consistent with previous analyses.

It is also worth noting that there were 85 topics that were discarded for this analysis. Most of these topics appear to be random distributions of numbers (such as topic 5: 000 1 500 100 400 200 10 300 600 800 700 total 20 250 50 3 30 900 150 750). These seem to represent page numbers or indexes that are sometimes present at the back of volumes. Considering that the

overall topic model contained 500 topics, this is a relatively small number of topics (17%) that were discarded for this analysis.

Overall, it would seem that the findings for this second analysis are consistent with those of the previous analyses. PAAAS does seem to be more involved in discussing theoretical topics, and business topics appear to be more frequently discussed in the later part of the nineteenth century. Most importantly JACS at least becomes more involved in discussion of business in the 1890s, the same period when the ACS is consolidating into a professional society with a clear identity separate from the AAAS. This analysis does, however, seem to add some nuance to the overall picture of science, however. Why do subjects such as astronomy and meteorology, subjects that were often so small in the other analyses that they were lumped together as “other sciences” appear relatively prominently here? Additionally, since physics was the next discipline to form a professional society, when did it become so prominent? The other topic models seem to show physics as equal to chemistry. Some of the answers to these questions may be matters of statistical significance, this analysis over the entire corpus is more consistent with the assumptions of Mallet. Nonetheless, both analyses seem to consistently point to the same general conclusions that are present in the historical analysis of this dissertation.

A Counterexample: The Career of T.A. Wylie

It is worth noting, however, that it was not inevitable that professional associations, universities, and journals became linked together to form the modern scholarly communication ecosystem. There were many prominent scientists who were not especially active in the associations that Alexander Dallas Bache founded and did not publish in the journals that so concerned George Barker, even though such scholars may have been well-respected in their fields. Theophilus Adam (T.A.) Wylie is an excellent example of a scholar who, though linked to the people at the center of these debates, acted very differently from his colleagues. Wylie's career, publishing patterns, and philosophy on education and science present a very different philosophy for communicating science at a time when the formal system of academic publishing was still in formation. Central figures including Alexander Dallas Bache and George Barker were perhaps among the most prominent voices in this debate, but they were certainly not the only ones.

T.A. Wylie (1810-1895), a faculty member in several different fields including natural philosophy, chemistry, and ancient languages, was the cousin of Andrew Wylie, Indiana University's first president; T. A. Wylie was also the chair of natural philosophy, and professor and emeritus professor of physics. Additionally, Wylie served as the university librarian, vice president, and as the interim president of Indiana University three times in 1859, 1860, and 1875. Outside of Wylie's university career, he was a Presbyterian minister and served as pastor of the Reformed Presbyterian Church in Bloomington.²⁸⁴ Importantly, Wylie was connected to many

²⁸⁴ Theophilus A. Wylie, *Indiana University : its history from 1820, when founded, to 1890: with biographical sketches of its presidents, professors and graduates and a list of its students from 1820 to 1887*. (Indianapolis: William B. Burford, 1890), 106-107.

Harry G. Day, "Introduction," in Elizabeth M. Greene *Theophilus Wylie: A Transcription from the Handwritten Copy of Original Diaries*. (Bloomington, IN: Department of Chemistry, 1987), v – x.

of the central figures who were active members of the *Lazzaroni* and founders of the AAAS. Wylie was a student at the University of Pennsylvania, a classmate of John Fries Frazer, and one of Alexander Dallas Bache's students. Bache, apparently, was not fond of Wylie whom he claimed was, "an everlasting, interminable bore. But must be borne."²⁸⁵ Bache and Wylie had quite different ideas on how science should be disseminated, and Bache's comment about Wylie may reflect some of his frustrations about Wylie's opinions. For Wylie, science, teaching, and natural philosophy (including both science and religion) were part of an overall system of higher education for teaching, research, and moral instruction that by the end of the nineteenth century had been largely discarded. By looking at Wylie's own ideas, it becomes clear that his scholarly communication patterns served a different purpose from those of his more prominent Penn colleagues and demonstrate an alternative way of thinking about how to communicate scholarship in nineteenth-century America, at least for Wylie and potentially other scholars throughout the U.S. as well.

The Purpose of Science and Education

In an undated talk "On Education" Wylie argued for a specific purpose of science and criticized those who emphasized "practical arts" (which might perhaps include industry). Wylie denigrated people who "are unable to go beyond first rudiments of knowledge, it is often time lost in endeavoring to develop powers of the mind which nature has not given them. For them something preeminently practical, which a machine might do – which can be done with the hands and without the brains is certainly best. It is nearly the same too with respect to those

²⁸⁵ Alexander Dallas Bache, "Letter to John Fries Frazer," April 18, 1844, Box 1, Item 36, John Fries Frazer Papers, Philadelphia, PA: American Philosophical Society Library.

whose sole object is to make money.”²⁸⁶ Rather, Wylie argued, “The object of education is the development of the mind, the drawing out of its powers, the preparing it for acting most efficiently in the proper time and place.”²⁸⁷

Wylie’s beliefs about science and education can also be seen in his other principal interest: teaching. From an early age Wylie also recognized his ability to educate. In his diary he said, “Teaching comes quite natural to me. I fear that it will be the trade into which I will eventually sink.”²⁸⁸ Forty years later, after teaching at Indiana University for many of those years, Wylie’s students wrote that Wylie’s “proficiency in his department, his eagerness, willingness, and energy, with which he instructs his classes leads us to say, none are like him, and none could fill his position as well as he.”²⁸⁹ Wylie gave many talks about education, and in all of these he stressed that the purpose of education is primarily “the development of the mind, the drawing out of its powers, the preparing it for acting most efficiently in the proper time and place.”²⁹⁰ Wylie emphasized that education provides students with tools that they can use, but it is impossible for students to use those tools without a kind of moral guidance that is essential in attaining the Wisdom to use those tools effectively.

Wylie made these points especially clear in a baccalaureate address he gave to Indiana University in which he said “Learning or knowledge is like a stock of goods, and wisdom the ability to arrange and display it, and dispose of it. In education it is of importance to acquire the stock of ideas, but of more importance to acquire skill in the arrangement of them.” This skill,

²⁸⁶ Theophilus A. Wylie, “Education,” Undated, “Sermons, lectures and public addresses 1835-1891,” Box 6, Item 27. Theophilus A. Wylie Papers, Bloomington, IN: Indiana University Archives.

²⁸⁷ Theophilus A. Wylie, “Education,” Undated.

²⁸⁸ Theophilus A. Wylie, *Diaries*, May 31, 1836.

²⁸⁹ Beta Theta Pi Fraternity, “Rev. T. A. Wylie, D.D.” *The Dagger*. 1 (1878), 2.

²⁹⁰ Theophilus A. Wylie, “Education,” Undated.

Wylie argued could be gained through wisdom which helps the student “avoid the dangers and grapple successfully with the difficulties and dangers he may meet in life. The wise man readily perceives the relations of things, ‘Wisdom’ indeed consists in the choice of proper ends and means.”²⁹¹ In another address Wylie clarified some of these points and suggested that “the principal aim of a teacher in the discharge of his duties.” Furthermore, teachers need to, “furnish the pupil with a stock of knowledge” because “[t]he development of the moral powers is frequently to these more of a disadvantage than an advantage.”²⁹² In another address Wylie even went so far as to wonder “whether then positions of atheistic teachers are tenable.”²⁹³ Thus for Wylie at least one can see that morality and natural learning are inextricably encompassed within the exercise of teaching.

The Purpose of Scholarly Publishing

Wylie’s emphasis on teaching also influenced the publication of his ideas. Overall, Wylie utilized many different methods for disseminating his ideas, but gave more prominence to his preaching and teaching rather than his publishing. Wylie published just twelve items during his lifetime including:

1. *Catalogue of the Library of Indiana State University* (1842)
2. Letter on gold found in Indiana read by Prof. John Frazer, *Journal of the Franklin Institute* (1850)
3. Letter on gold found in Indiana read by Prof. John Frazer, *Proceedings of the American Philosophical Society* (1850)
4. “Teeth and Bones of Elphas Primogenius, Lately Found Near the Western Fork of the White River in Monroe County, Indiana” in *American Journal of Science* (1859).

²⁹¹ Theophilus A. Wylie, *Baccalaureate Discourse to the Graduating Class of the Indiana State University*. Indianapolis: Indianapolis Journal Company, 1859.

²⁹² Theophilus A. Wylie, “Education,” Undated.

²⁹³ Theophilus A. Wylie “Truth,” 1878.

5. *Baccalaureate Discourse to the Graduating Class of Indiana State University*. (1859)
6. "Andrew Wylie, D. D., First President of Indiana University" in the *Indiana School Journal* (1860)
7. "The Meteors of November 13-14, 1867 observed at Bloomington, Indiana" *Monthly Notices of the Royal Astronomical Society* (1867), published by Daniel Kirkwood's but Wylie is mentioned as contributing.
8. "Interesting Report of Prof. Wylie of the State University." *Indianapolis Journal* (1869)
9. "Rain of Spider-Webs" *Scientific American* (1881)
10. "The Connection of the Mind with the Material World" *The Current* (1886)
11. "Hoosierisms" *The Current* (1886)
12. *Indiana University: Its History from 1820, when Founded to 1890* (1891)

If one looks at all of Wylie's outputs (lectures and publications alike), there is one common denominator: the audience for which they were intended. Only four out of his twelve articles were likely intended for fellow scientists. The rest were intended either for students or for members of the public. The library catalogue is not explicitly attributed to Wylie but is likely his work.²⁹⁴ Four of the articles were distributed in scientific journals (*American Journal of Science*, *Journal of the Franklin Institute*, *Proceedings of the American Philosophical Society*, and the *Monthly Notices of the Royal Astronomical Society*). The rest of Wylie's publications comprise newspaper articles (*Indianapolis Journal*), articles in popular literary (*The Current*) and scientific (*Scientific American*) magazines and educational newsletters (*Indiana School Journal*). Additionally, Wylie published one of his Baccalaureate addresses, and the work for which he is best known, *Indiana University: Its History*, a history of Indiana University written for alumni and other members of the university community.

²⁹⁴ Mildred Lowell, *Indiana University Libraries, 1829 – 1942*. (Chicago: University of Chicago, 1957), 43.

Overall, T. A. Wylie, saw a much clearer relationship between his research interests linking science, religion, and natural philosophy into an educational mission that he disseminated both to his students and to the wider public. Wylie put much more emphasis on his teaching, and less on his publishing during his tenure at Indiana University, and serves as a counter-example to the ideas of Bache and others. Wylie was in close correspondence with many of the leaders of science and higher education. Nonetheless, Wylie did not work to create an aristocracy of science served through a professionalized publishing system. Rather Wylie educated a variety of different publics primarily in his teaching, but also in a wider variety of publishing venues.

Conclusion

Wylie is just one example of no doubt many scientists who acted in ways different from Alexander Dallas Bache, George Barker, and some of the more prominent American Scientists. Wylie wrote a series of scientific lectures, sermons, and articles for a mostly local, rather than national audience. Wylie's teacher, Alexander Dallas Bache, had a very different view. In a speech he gave to the Franklin Institute in 1842, Bache stated that, "voluntary associations for the improvement of agriculture, manufactures, and the arts, exist all over our country, not supported, it is true, by our great sovereign the people, but by a few, who are either immediately or remotely interested or who desire to advance the weal of their country. If the eyes of this most august sovereign might but be opened to the importance of fostering these institutions!"²⁹⁵ Bache was criticizing the fact that small institutions spread around the United States were fostering science for local audiences and often in an inconsistent manner. Furthermore, Bache was advocating for a national movement to support more consistent promotion of science and the formalizing of scientific organizations.

For Bache and his supporters among the *Lazzaroni*, scientific societies like the AAAS and government agencies such as the National Academy of Sciences and the Smithsonian should serve as a means to nationalize scientific efforts in the United States. Additionally, such national institutions should create an aristocracy of science that would exclude charlatans and others who might embarrass American scholars who were interested in creating research comparable to what was being produced by their colleagues in Europe. To do this, the *Lazzaroni* used what influence they had, the access to government patronage and the money that came with it to reform

²⁹⁵ Alexander Dallas Bache, "Address delivered at the close of the Twelfth Exhibition of American Manufactures," 386.

organizations like the American Association of Geologists and Naturalists into a national organization under the control of Bache and his colleagues. Ultimately, however, their plan to create a national organization for science controlled by Bache and his circle was unsuccessful.

Why was Bache's dream of creating a centralized aristocracy of science not possible in the United States as it had been in Britain, France, and Germany? Even Bache and his colleagues would have been able to give a partial answer that question. During the formation of the AAAS, leaders of the organization struggled with the need for specialization within the society. Specialization helped to answer ever narrower questions, and, more importantly for people like Bache, specialization helped to meet the needs of industries that needed products to bring into the market and resources (mines and chemical formulas) to create those products. Early presidents of the AAAS realized that specialization if taken too far, could jeopardize the possibility of centralizing all scientific activity through the AAAS.

In time, Bache's fear of AAAS splitting into multiple societies was realized. George Barker, himself a president of AAAS and, like Bache, a faculty member at the University of Pennsylvania, helped found the ACS. In some ways Barker's efforts were similar to Bache's. Early leaders of the ACS also wanted to create a national and centralized organization for chemistry. ACS organizers wanted to create their own discipline-focused aristocracy of science. Ultimately these scientists working in more specialized societies were more successful, than Bache and his colleagues had been. Why? Barker and his fellow leaders also created more specialized groups within ACS, that were modeled upon AAAS' specialized sections. Additionally, however, leaders of the ACS realized early the need to control the information flow within ACS in a way that Bache and the *Lazzaroni* never seem to have realized or assumed could be handled in existing journals such as *AJS*.

American journals at the time seem to reflect this reality of scientific communication in the nineteenth century. AJS was the primary means of distributing scientific information during much of the nineteenth century. AJS was not under the control of any society, but rather under the control of one of the most prominent scientists at the time, and a member of Bache's circle, Benjamin Silliman. Silliman's journal, as AJS was called, started out as a news source for many scientific practitioners around the United States; it also specialized in geology, the most popular scientific discipline at the time. Though Silliman's journal initially published articles from many disciplines like Astronomy and Physics, by the twentieth century it specialized entirely in geology. PAAAS, a journal that overlapped with AJS in its period of publication (until ceasing publication in 1914), is quite similar to AJS. PAAAS also published articles about many different disciplines but served even from its inception as a news distributor for the society. Unlike AJS, however, by the twentieth century PAAAS became entirely devoted to news (mostly contact information about members of the society), whereas AJS became more dedicated to articles about geology and less interested in distribution of news.

JACS combined many of the characteristics of both AJS and PAAAS. JACS specialized in publishing about chemistry from its inception. News and professional topics were a rather small, but consistent, part of what JACS was publishing. Over time, however, it becomes clear that chemistry as a topic declined in both AJS and PAAAS. More importantly, this decline happens at exactly the same time ACS forms its own society separate from AAAS. Thus, one can conclude that ACS became a more desirable venue for communicating chemistry research. Additionally, topics covering professionalization and news increased at the same time. Therefore, one can hypothesize that JACS becomes a more important news source both for professional issues and for chemistry among practicing chemists in the United States. This is not

a surprising inference. George Barker and the early leaders of the ACS were quite interested in making sure that their newly founded organization had greater control of information flow than those who oversaw AJS, PAAAS, or indeed the organization of the AAAS.

Why is this link between professional organizations and journals important for modern scholars of scholarly communication? One might suggest that Bache never truly opened the eyes of the public as he alluded to in his speech, but simply substituted one small dispersed group of people who promoted science with a different small group of nationally focused professionals. Furthermore, Bache stated that, “While Science is without organization, it is without power: powerless against its enemies, open or secret; powerless in the hands of false or injudicious friends.”²⁹⁶ In order to create “power” in science, Bache created national and centralized organizations such as the AAAS, but without any clear way of controlling the information flow for those organizations. George Barker and the early leaders of ACS also were interested in creating the same centralized and national institutions but did have a greater concern with controlling communication in chemistry.

Christine Borgman has suggested that the journal article is the cornerstone of the scholarly communication system that the article has remained, “remarkably stable and print publication continues unabated, despite the proliferation of digital media.”²⁹⁷ With this historical analysis of scholarly communication, one might go further to say that the journal article is part of a larger social system including professional societies and power structures within the sciences. These social systems have their origins, at least in the United States, in the nineteenth-century.

²⁹⁶ Spencer F. Baird, ed. *Proceedings of the American Association for the Advancement of Science*. New York: G. P. Putnam, 1852, lii - liii.

²⁹⁷ Christine Borgman, "Digital libraries and the continuum of scholarly communication", 413.

This dissertation intended to accomplish several aims. First, it proposed to better understand how and why professional associations, universities, and journals intersected. Second, it attempted to bring together both qualitative sociological-historical and quantitative computational-statistical methods to make a more nuanced argument about how journals interact with larger social forces within nineteenth-century American society. Finally, and perhaps most importantly, this dissertation aimed provide a different framework for discussing modern issues about scholarly communication.

At a time when “academia has lurched from crisis to crisis in scholarly communication for too long,”²⁹⁸ when bibliometricians are noting problems within scientific publishing,²⁹⁹ and when scholarly communication practitioners have advocated for addressing such issues, it is important to think about why the scholarly communication system is in crisis. Though this dissertation does not entirely answer how scholarly publishing contributes to such problems, it does provide a part of the answer. Scientometrics and quantitative methods can help to show how the journals reflect underlying realities. History, sociology and more qualitative methods can help to answer the answer of why such realities exist. This dissertation has begun to reveal the origins of power relations in science in the nineteenth century. By learning more about how the scholarly communication system evolved and by demonstrating to practicing librarians and publishers the reasons for the scholarly communication system’s underlying sources of power, one can only hope that more informed and more lasting solution of the crisis in scholarly communication can be created.

²⁹⁸ Dave S. Ghamandi, “Liberation through Cooperation: How Library Publishing Can Save Scholarly Journals from Neoliberalism,” *Journal of Librarianship and Scholarly Communication*, 6, no. 2 (2018): 2.

²⁹⁹ Vincent, Lavrivière, Chaoqun Ni, Yves Gingras, Blaise Cronin, and Cassidy R. Sugimoto, “Bibliometrics: Global Gender Disparities in Science,” *Nature News*, 504 (2013): 211-213.

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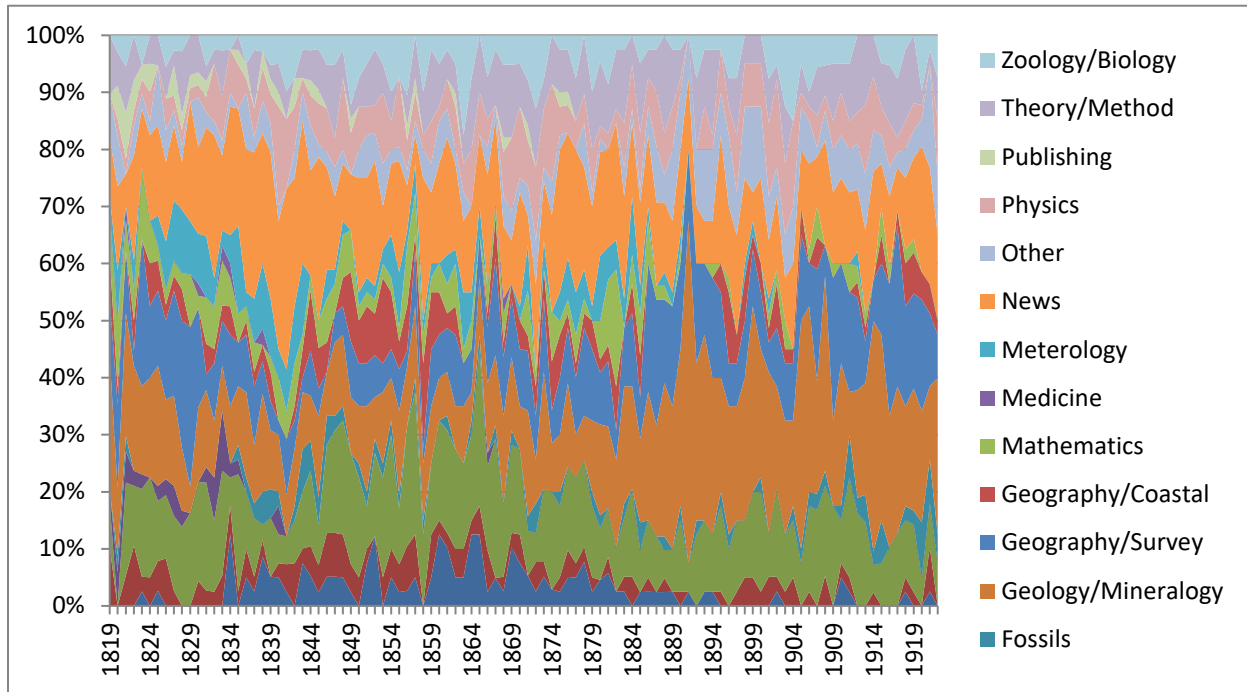
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Appendix I

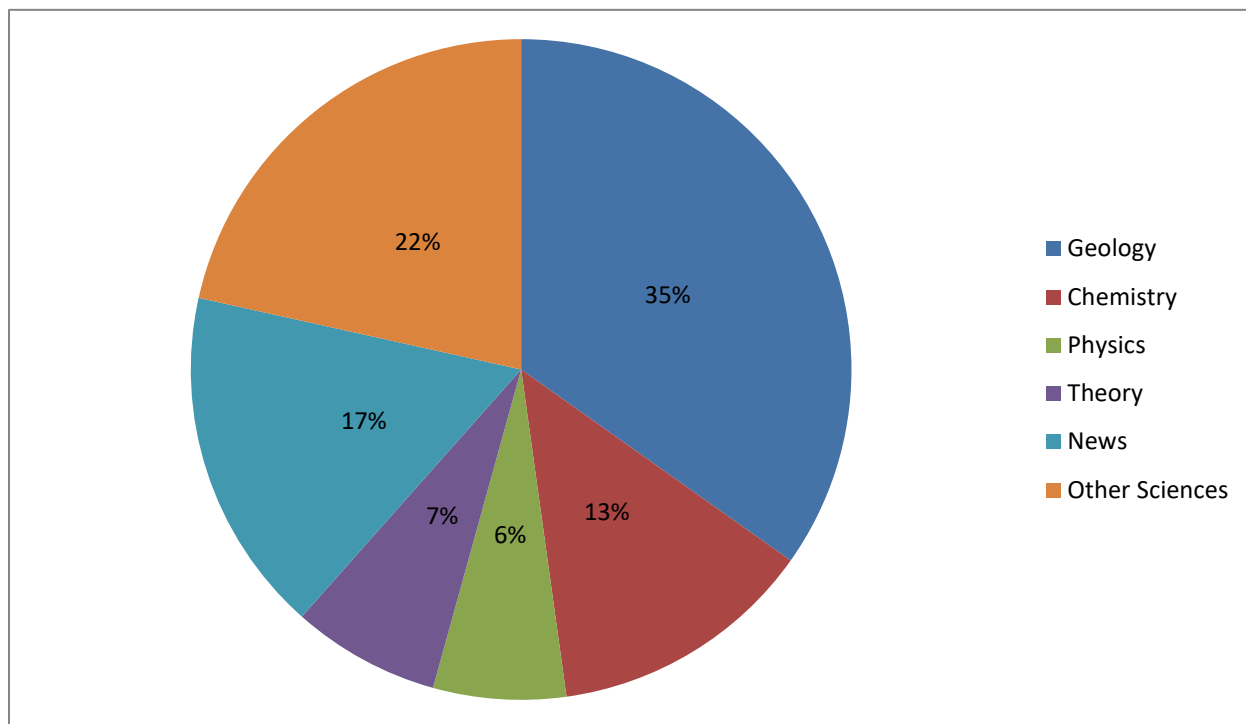
Visualization of the percentage of all categories in the *American Journal of Science*

1819 - 1922



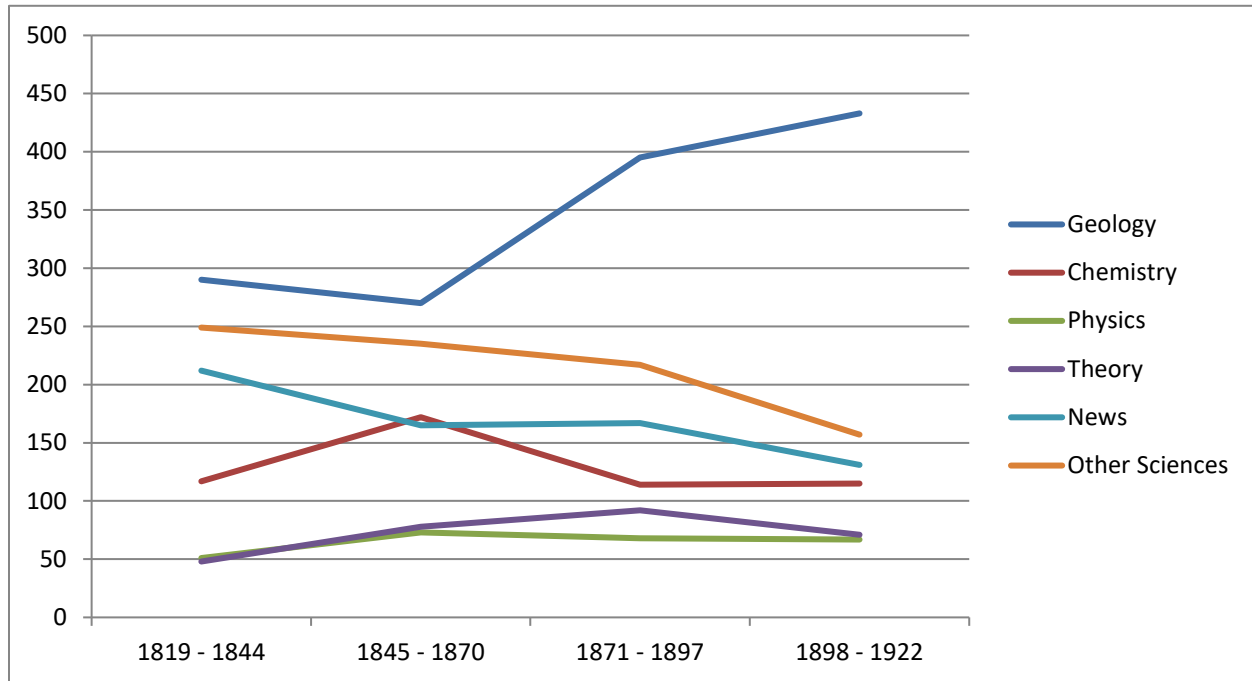
Appendix II

Percentage of Topics in the *American Journal of Science* All years 1819 - 1922



Appendix III

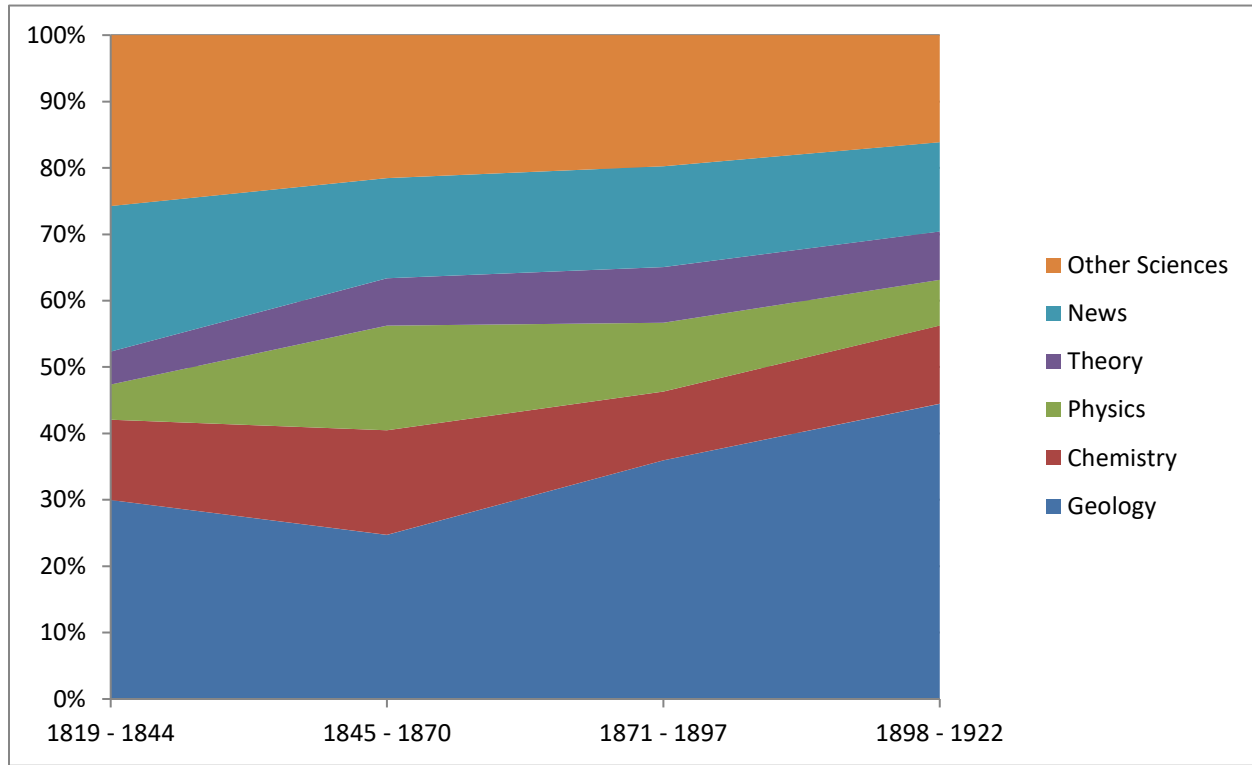
Trends in number of topics in the *American Journal of Science* 1819 - 1922



Appendix IV

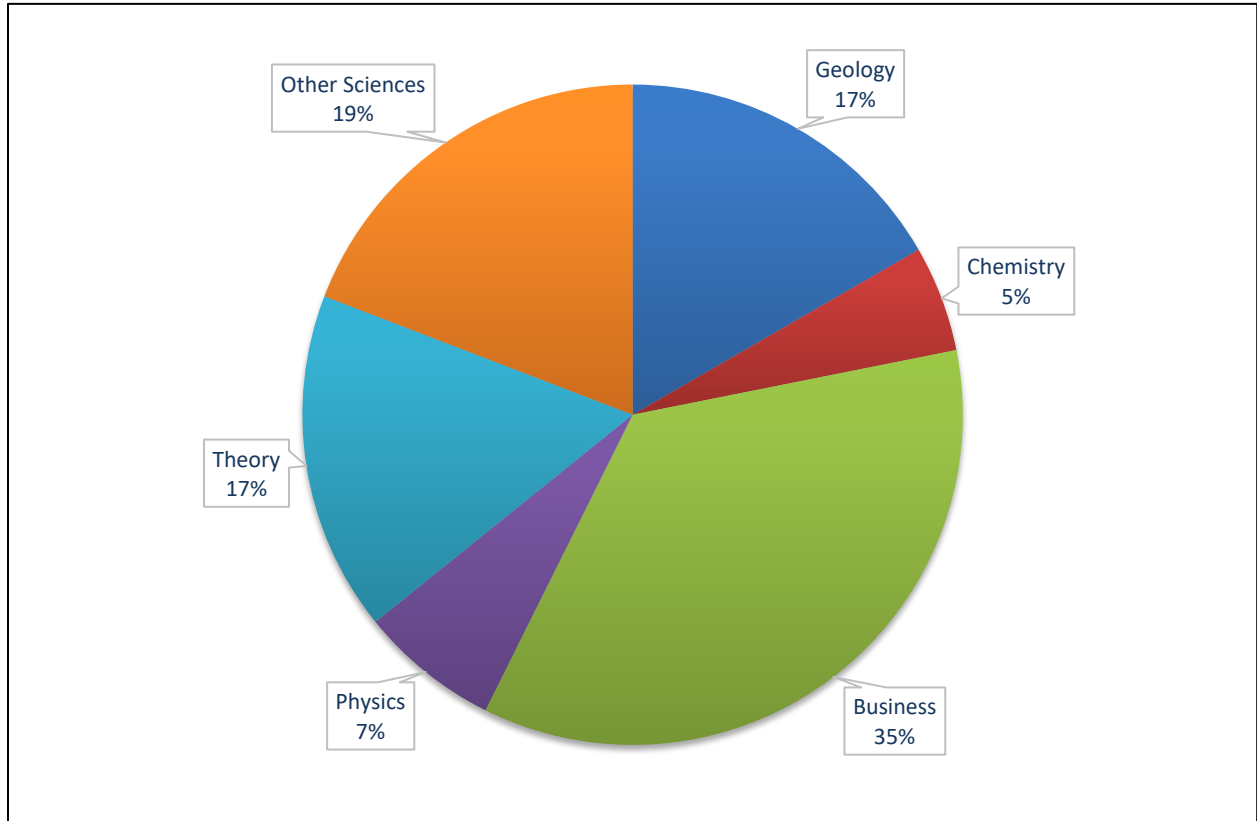
Topics represented as a percentage of the whole in the *American Journal of Science*

1819 - 1922



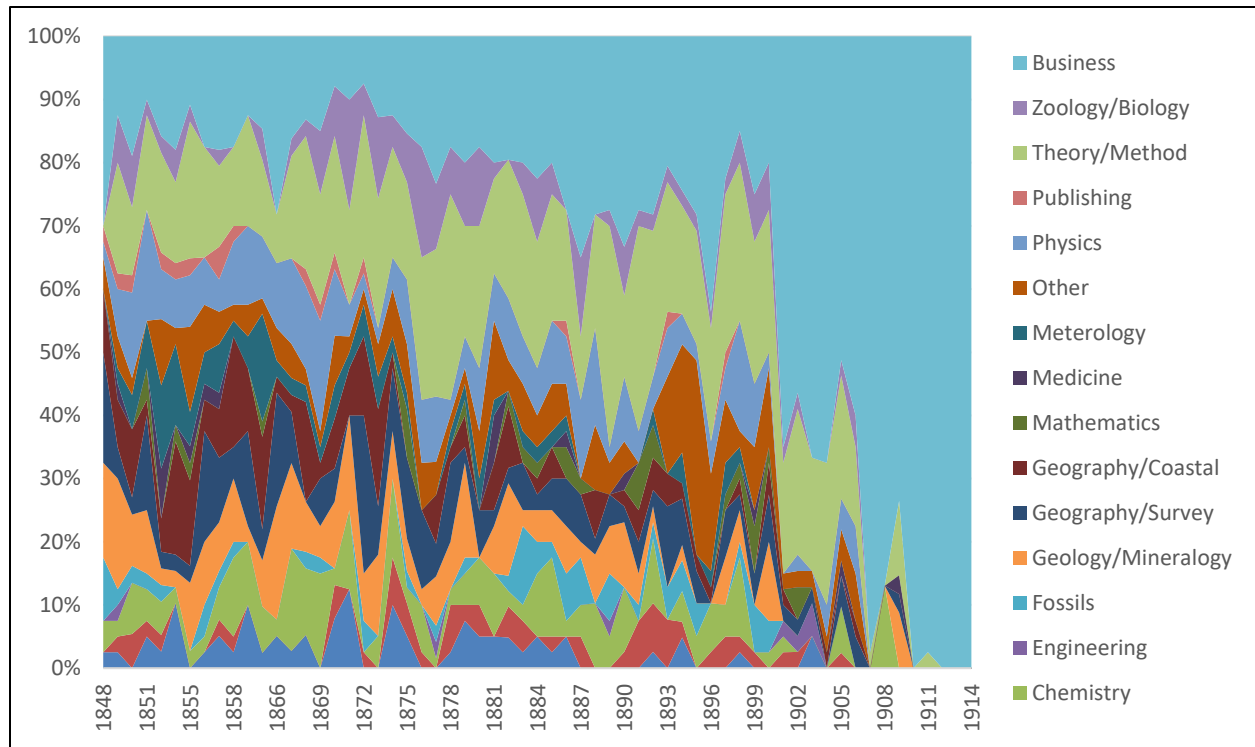
Appendix V

Percentage of Topics in the *Proceedings of the American Association for the Advancement of Science* All years 1848 - 1914



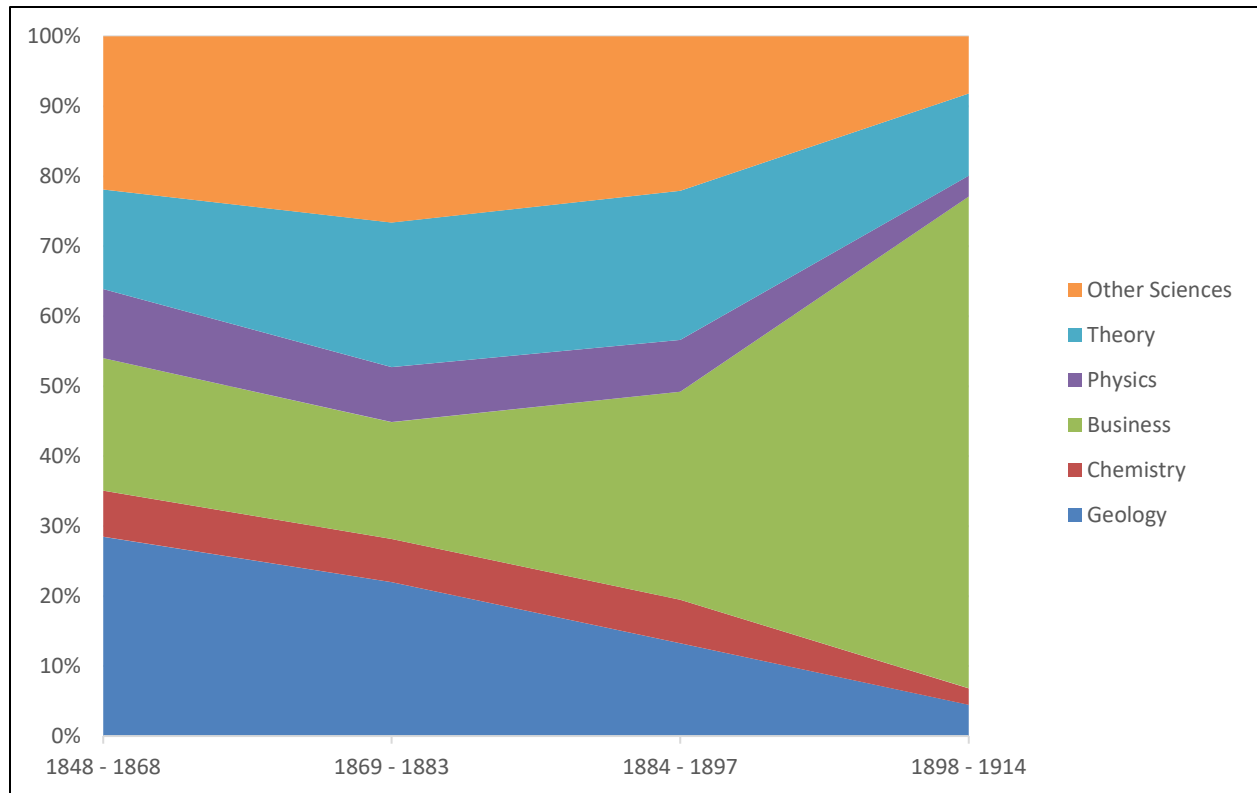
Appendix VI

Percentage of all categories in the *Proceedings of the American Association for the Advancement of Science* 1848 - 1914



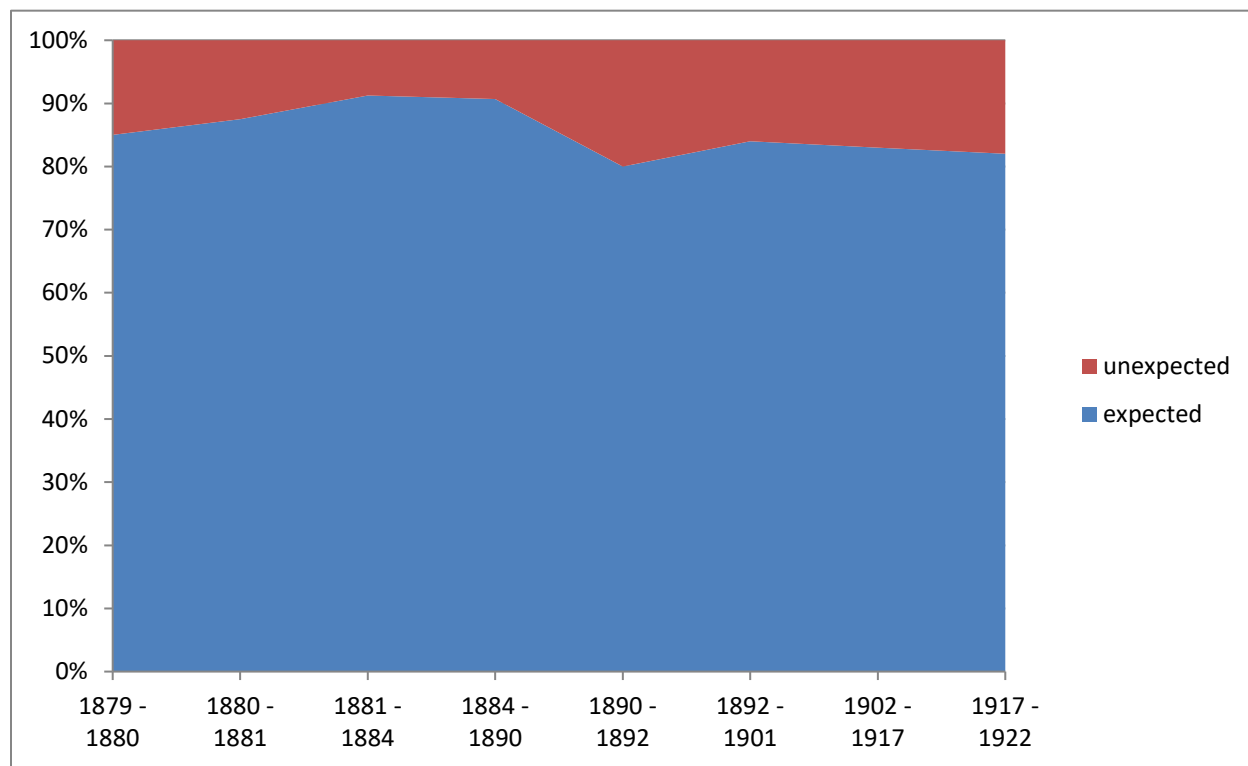
Appendix VII

Topics represented as a percentage of the whole in the *Proceedings of the American Association for the Advancement of Science* 1848 - 1914



Appendix VIII

Distribution of Expected and Unexpected Topics grouped by editorial years - *Journal of the American Chemical Society* 1819 - 1922



Appendix IX

Topic Model of All Journals Utilizing Documents of 1,000 Words

Topic Id Top Words...

- mammals forms eocene teeth cope extinct horse evolution mammalia primitive foot genera
- 0 group modern order america early type american types
layer layers upper lower surface thin hard thick thickness soft covered part gn material
- 1 bottom film mass contact separated distribution
iron steel nickel manganese phosphorus cast aluminum titanium chromium metal copper
- 2 silicon metals sulphur ores pig ore alloys cobalt alloy
committee noyes charles chairman william edward wm smith john arthur parsons howe chas
- 3 lewis editor long hillebrand talbot january hart
wine wines car tory labora genet satisfac ried memorial ale jones tories 1 trial fermentation
- 4 natural balloon red kelly palestine
- 5 000 1 500 100 400 200 10 300 600 800 700 total 20 250 50 3 30 900 150 750
- 6 1 2 3 5 4 6 7 8 9 18 20 16 12 19 17 10 13 21 14 15
length side surface long form base small large inch diameter inches half part edge size upper
- 7 sides middle line end
fire air room chamber wood building floor house brick walls pipes pipe iron open fuel rooms
- 8 wall ashes roof buildings
corundum emery dif minor asia smith carolina spinel ferent pratt ruby mass lawrence found
- 9 dunite smyrna sapphire diaspore chester chromite
tellurium selenium dioxide te telluride 127 selenic selenious selenate telluric se sulphur
- 10 selenide tellurate bismuth tellurous compound found tellurite lenher
lime water carbonate waters springs magnesia carbonic sulphate spring acid mineral matter
- 11 gypsum calcium carbonates soda iron organic silica analysis
- 12 ne char se po sw nw lated gm tassium calcu acter nne ene acteristic usable sse jv ssw nnw ese
- 13 8 6 5 4 2 3 7 9 0 1 10 11 12 trace 73 184 mgs oj 102 469
6 5 7 4 8 3 2 1 naphthoic dihydro io appre dihydronaphthoic 2048 a2 1024 labile kamm ciabile
- 14 oliver
specific gravity volume density water weight volumes gravities densities expansion
- 15 determined found equal determinations difference made weights liquids pycnometer float
term terms general called case true present sense relations defined definition relation form
- 16 definite considered question paper applied expressed conditions
rocks rock granite igneous schists contact quartz origin series gneiss dikes crystalline magma
- 17 region masses eruptive granitic sedimentary metamorphism great
day water great night left place hundred called side days ground beautiful morning high party
- 18 mountain passed reached time fire
san california mexico francisco colorado sierra santa nevada rio valley pacific de arizona del la
- 19 utah river grande desert south
hall sp species fossils limestone spirifer meek carboniferous permian devonian productus
- 20 atrypa orthis upper geinitz swallow athyris chonetes rocks var
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 22 salt constant table data measurements calculated equivalent ions solution chloride
 association meeting secretary committee members president general section council sections
 23 member vice officers permanent meetings science elected art standing proceedings
 water hydrate hydrated anhydrous crystallization temperature transition hydrates form
 crystals temperatures forms stable anhydride hydration composition dehydration hydrous h2o
 24 solubility
 soil soils plant crop humus plants organic crops matter lime potash agricultural food nitrogen
 25 manure acre mineral fertilizers growth pot
 flame combustion gas air heat burning burner bunsen lamp oxygen heated jet ignited ignition
 26 blast flames gases tube burned burn
 cent 1 total average percentage found percent amount results gave loss analysis 100 10
 27 calculated 50 analyses contained obtained 20
 cloud air storm lightning earth tornado thunder hail explosion wind house ground clouds fell
 28 trees heard violent storms track rain
 time place formed mass form formation process surface gradually portion part point rapidly
 29 case contact long slowly change condition takes
 hood holmes dwarf league dwarfs hooper holt sachems holden iroquois mohawk sachem
 30 hoffman wampum onondaga hoe hunter perf seneca hodge
 hydrazine acid aldehyde hydronitric oxidation trinitride ammonia oxidizing nitrogen formed
 formation agents obtained action acetaldehyde formaldehyde yield reduction hydrate
 31 products
 gens crustacea pole tribe torrid cabinet edw carapax sacred charleston boston omaha biloxi
 32 edwards gentes wa temperate haan macroura totem
 potassium cyanide cn ferrocyanide arsenate lead cyanogen thiocyanate cyanides chloride
 33 solution ferricyanide fe hydrocyanic excess ferric reaction formed sodium hydroxide
 difference differences differ case slight marked due show found identical ence higher shows
 34 lower differs ent find fact alike ences
 current motion direction currents surface air movement action atmosphere force opposite
 35 earth rotation stream side effect moving upper axis equator
 matter organic odor volatile coloring taste matters substances sweet beer color spirits bitter
 36 wine spirit wood composition smell whiskey flavor
 heat energy cal calories heats calorimeter specific free combustion temperature bomb
 37 formation capacity reaction gram data total values af thermal
 magnetic needle force field magnetism intensity magnet earth lines poles currents dip pole
 38 variation north direction action terrestrial horizontal effect
 solubility solution solvent solutions water saturated salt salts solvents solubilities solu
 39 dissolved concentration product pure added bility solid 2 liter
 good order poor fair bad quality form main follow fairly deal easily give excellent proper
 40 extremely ph thi make poorer
 found small color specimens white crystals mass masses specimen black surface large form
 41 structure fine appearance quartz grains green fragments
 lava crater volcanic eruption feet volcano lavas cone eruptions lake kilauea great cones
 42 summit volcanoes loa action mountain flow island
 quantity amount small portion present quantities found obtained weight added equal
 43 required large time part contained equivalent total case made
 nuclei air fog coronas case viscosity barus cm data chamber 1 particles large number
 44 exhaustion experiments small time present question

xi geology xii xiii xv xiv xvi xix xviii xvii index rocks xx geological marsh american dana report
 45 light minerals
 fort laramie river colorado dakota hayden wyoming creek denver hills park montana fox
 46 missouri yellowstone union region bear pierre utah
 oil petroleum hydrocarbons tar oils bitumen pitch asphalt distillation crude gas naphtha
 47 products paraffin bituminous california light heavy asphaltum wells
 quartz minerals crystals mineral calcite locality specimens tourmaline garnet topaz crystal
 48 mica beryl rare fine large zircon county feldspar occurrence
 fathoms sea depth bottom deep depths coast water verrill soundings fauna gulf surface ocean
 49 large bay stream obtained marine great
 ore iron mine mines ores copper veins vein deposits found mining quartz lead mineral district
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 58 tertiary pecten common carolina gulf shell miocene
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 copper lead zinc metal bismuth silver sulphate metals tin oxide alloy aluminum cuprous cu
 61 alloys metallic cupric acetate iron pure
 earth surface crust density globe depth mass gravity miles fluid terrestrial solid level shell
 62 compensation interior tidal ocean rotation isostasy
 ammonia ammonium nh liquid salt amide solution salts nh3 formed nitrogen free ammo
 63 franklin monia urea nh4 formation nitride gas
 min pt max temp 10 aquo cobaltic table werner av utes det hrs pentammine dev mhos 1
 64 chloroplatinate expt mm
 species genus genera specimens found forms number characters american form distinct
 65 common family group specimen specific referred allied belong represented
 grm acid 0 found experiments table cm3 amount solution volume gooch sulphuric error made
 66 process 10 results hydrochloric ammonium estimation
 substance obtained pure product preparation products found prepared material made
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 body organs eggs legs male pair head mouth female segments animal egg young cavity
 68 embryo abdomen structure joint appendages anterior
 stars star comet observations observatory tail magnitude nucleus telescope nebula motion
 69 astronomy observed discovered double distance planet catalogue mr elements

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 marble georgia knox deformed deformation bradley ditto ocoee partly wallace obser ga jasper
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 long leaves fruit spikes ovate plant species culm short spike pistillate oblong scale lanceolate
 81 base boott high erect staminate shorter
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 82 resultant optic points convergence perspective point
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 cc solution 1 10 5 100 added grams water 50 2 volume 25 20 gram minutes made 200 15
 90 mixture
 north south america northern coast sea regions southern ocean land europe islands west
 91 arctic latitude atlantic great continent east eastern
 vinegar inter cider nal fission apple fermentation yard metre date solids origi marc imperial
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 resistance current circuit coil wire galvanometer electrical coils capacity cell ohms deflection
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air water weight heated dry dried temperature heating loss tube hours moisture drying
 96 weighed current sample material lost boat found
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 mineral analysis material gravity specific composition found analyses chemical gave color
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 silica soda lime alumina potash iron magnesia caustic silicate carbonate water silicates alkalies
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 alcohol ethyl methyl ether acetone acetate amyl alcohols iodide ester water propyl butyl
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 observations made latitude longitude observation results time observatory survey meridian
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 electrons atoms atom electron valence number theory polar atomic positive elements
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 friction porto mate rico schuylkill surfaces coefficient spring journal frictional garden rubbing
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 mercury mercuric amalgam hg thallium amalgams mercurous mer chloride metallic metal
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 rock feldspar rocks hornblende quartz augite mineral minerals grains biotite olivine pyroxene
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 texas cretaceous hill marcou mexico kansas comanche arkansas dakota cragin division washita
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 182 obtain find form term quantities
 surface drop tension liquid liquids weight capillary drops water tip benzene morgan rise gun
 183 tensions falling ramsay tc tate density
 184 ao jo 3hx 3 ag ahx ni av 30 hhx xg ox bhx aq anx ay 9 shx xi xo
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 186 huatanay pasco inca reconnaissance fan 11 ano
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 192 miscellaneous volume academy 8vo professor states science journal
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 193 obtained compound ethyl esters aniline derivative acids products prepared
 194 jo 9 9q 8 01 99 uo eq qj qi oj 81 dd 8i 09 3 91 os si 88
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 200 pentachloride phos derivatives action prepared phorus mixture aniline reaction
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 201 geol chemistry index american fossil north page british van
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 209 ethylamine organic obtained formed piperidine products quaternary strychnine free
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 210 number modifications chlorate features structural zone perchlorates
 velocity force motion time distance body equal direction resistance velocities point unit
 211 moving space length proportional forces mass square line
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 212 point power manner time common nature
 flask water bottle glass allowed liquid added time temperature flasks bottles contents minutes
 213 weighed shaken small shaking hours mixture stoppered
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 217 obtained liquid carbonic heat action salts decomposition
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 224 comparison calculated total op show
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 225 discharge volts light tube obtained ray pressure

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226 north great waters valley bay
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227 sandstones red bed fossils conglomerate series rocks thin
228 ch nh cooh ch3 ii ch2 br h4 formula compound h5 chs hc hs choh h6 och cn oc nh2
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229 angle edges figures prismatic face basal crystallization
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237 geological deposits eocene miocene jurassic upper formations
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239 expansion
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240 compounds quinone compound toluene ethylene anhydride nitro xylene phenols
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241 reducing rotatory juice invert fructose beet dextrose molasses polarization
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246 sorption absorbs absorbent energy ually complete light
247 de la des les paris du sur le par en dans france sciences qui est chimie une physique pour tome
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248 common teeth length family gill tail long
force energy forces molecules molecular action attraction heat atoms chemical matter mass
249 bodies elastic stress molecule strain repulsion body mechanical
alkaloids alkaloid quinine morphine opium bark drug alcohol extract pharm drugs strychnine
250 properties sulphate assay resin brucine cinchona cocaine plant

251 ca na sr br ba li cs al si ci ti mg ag pb au tl cr hg cd zn
 heat heated platinum crucible metal fused fusion mass glass red iron charcoal hot water
 252 melted small mixture porcelain white furnace
 solution precipitate acid water precipitated added dissolved filtered excess washed filtrate
 253 precipitation ammonium hydrochloric treated boiling ammonia hydroxide chloride dilute
 action destruction saligenin ribbon ribbons edgewood protective bowling act salicyl attacked
 254 sexton disalicyl pike acts cyrene mills saligenate typewriter attack
 end made inch rod inches cylinder diameter brass wire top small box apparatus attached side
 255 piece means bottom disk lower
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 256 crystals crystallization compound temperatures silica form system ternary cooling
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 257 american geological coal notices mineral minerals _ action plants
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 258 equal parallel distance radius horizontal axes
 iodine iodide bromine potassium bromide solution free chlorine iodate starch reaction excess
 259 br hydriodic ki iodides thiosulphate iodic hydrobromic action
 action effect produced effects influence due chemical results found substances result
 260 presence case experiments produce shown change observed production power
 furnace iron ore blast cent tons furnaces coke process ton steel richards eng ores slag coal
 261 production works min gas
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 262 relation holds expression simple applied hold dulong
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 263 formed alkaline form lead formation product mineral action
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 264 carpenter similar chambers canadense filled sections canals microscopic wall preserved
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 266 account case explain conclusion point shown support favor based
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 267 cast shape bronzes object casting produced condition rounded shows
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 268 botanist north natural herbarium plates zoology orders
 cotton seed meal oil cottonseed lard miller whitney fat gun fed hay cake hogs wool feeding
 269 halphen cholesterol lards ration
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 270 cal boston john west brooklyn
 cells cell wall walls protoplasm nucleus contents division membrane granules living formation
 271 outer nuclei formed substance evi cellular process form
 diffusion key music scale musical perfect notes major minor note intervals harmony
 272 temperament organ keys octave chord chords intonation temperaments
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 273 price professor james year monthly cambridge gray mining
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 275 human nature research field day study country

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 277 effect cond ii theory aq
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 278 extraction kola tannate soluble powder extractor
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 280 physics thai D° $\text{D}\pm$ ind department
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 281 pot extract average veal proteid frozen
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 287 titanium silicide piperidine silicides amorphous tetrachlorides carborundum heptane
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 288 vapor liquid molecules molecular substance state relation data absolute
 289 120 112 106 125 108 107 105 121 122 118 113 110 115 114 117 124 130 109 119 103
 dye aniline dyes coloring indigo blue azo red compounds diazo wool colors dyeing sulpho
 290 naphthol action tar matter color matters
 water filter acid solution residue crucible weighed platinum washed precipitate dish add
 291 paper filtrate wash evaporated hot washing weight beaker
 light lamp power candle lamps candles incandescent electric standard lights intensity
 292 illuminating soap illumination photometer consumption photometric efficiency arc made
 meteors aurora light observations time sky horizon meteor observed night stars clock north
 293 evening morning visible shooting november auroral minutes
 color red blue yellow green colors colored violet white light orange colorless deep brown dark
 294 purple pink tint bright reddish
 sand clay gravel deposits surface water deposit feet material formation beds pebbles drift
 295 rock bed clays sands bottom river mud
 sun earth orbit moon planet planets solar system motion distance orbits mass jupiter comets
 296 rotation bodies theory motions saturn satellites
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 297 chair breneman chemists waller
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 298 original represents surface sections upper block
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 299 complete time result unchanged alteration changing gradual shown taking
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 304 carbide bisulphide car free oxidation calcium disulfide bon graphite atmosphere
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 305 notes note inorganic quantitative physical qualitative compounds separation laboratory smith
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 306 products dairy fresh oleomargarine protein albuminoids
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 307 electrical waves energy wave velocity size gravitation surface
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 308 purpureocobalt roseo co2 iron xanthocobalt purpureo luteocobalt
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 309 soda alkali alkaline sulphuric dye zinc pa
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 310 detection give results qualitative testing drop coloration
 committee report secretary congress appointed international members council meeting year
 311 association account library fund chairman treasurer adopted committees received society
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 312 permeable dialysis porcelain skin mem pass pores osmosis passage effects mod
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 313 owen origin flexor tendon wyman tendons extensor
 instrument scale position telescope mirror distance made micrometer length screw means
 314 method axis adjustment apparatus microscope field reading vertical glass
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 315 upper limestones slates hudson taconic trenton sandstone
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 318 tank germs medium purification matter sanitary filtration chemical septic
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 320 2 3 1 4 5 8 ratio 22 op 2i oj 2j oi 2t el 180 2o 2x i5 304
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 321 temperatures
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 322 government countries england statistics great canada congress world
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 323 general state interest states congress president united men members
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 324 remarks studies demonstration sizing problem economic

325 487 486 488 484 483 485 500 482 505 501 489 503 481 509 507 498 504 493 495 490
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 326 similar order carried table showed show time determine repeated
 acid solution potassium sodium permanganate hydroxide excess titration added amount
 327 method oxidation hydrochloric standard alkaline alkali titrated solutions reaction present
 method process time great found large employed required difficulty operation order means
 328 case advantage form complete good purpose made simple
 clark clarke chapman clapp chandler washington latham horny reagan chester monte alvan
 329 church south chamberlain bullock chittenden worcester tip cheney
 names nomenclature word words language english adopted terms system term original
 330 proposed latin greek languages french rules rule author called
 331 60 66 63 65 62 58 64 61 57 67 59 68 56 69 54 71 52 9 72 60
 process apparatus manufacture gas water consists oil patents lime making patent american
 332 wood steam coal method composition soda mixed mixture
 physiol blood action underhill med serum toxic biological nucleic physiological proteid effect
 333 animal urine chemistry proteids tissues chemical injection tissue
 sound sounds vibrations ear musical heard tone pitch vowel bell sonorous note tones pipe
 334 produced air sensation hearing telephone beats
 high low higher lower temperatures highest grade lowest temperature slightly content case
 335 shows account grades percentage good give form large
 samples sample analyses ash analysis cent composition flour wheat made results content
 336 percentage average total gluten protein analyzed commercial table
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 337 economic jordan stewart mck cox society science
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 340 case nega electrical neutral sum electric ions electricity
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 341 observed find character presence greater form
 342 200 100 150 300 60 50 20 120 90 250 40 400 80 30 10 180 5 25 140 70
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 343 series square figures scale give tables divided
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 347 io i3 3o i5 4o 5 5o 4 oo ii ioo 6o 8o 4i 3 i2 i4 3i i0 i8
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 348 melting terminal feet snow phenomena period northern
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 349 area pressure clean

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 350 es noted due considerate type practically region
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 351 connecticut miles mississippi lower upper flow plain mouth
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 352 wheel horse force working pounds boilers stroke weight
 bones found remains mastodon bone fossil teeth skeleton fragments inches elephant human
 353 broken feet discovered pieces mammoth large heaps small
 station agr bull expt agricultural sta experiment pp bulletin dept report agriculture bureau
 354 chemistry state regia lawson aqua rep department
 acid phosphate phosphoric phosphates ammonium phosphorus phos calcium molybdate
 citrate magnesium ammonia solution soluble pyrophosphate citric magnesia results phate
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 356 90 95 99 88 92 89 91 94 93 87 86 96 98 97 85 84 100 83 80 82
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 357 low direction west north east stations states
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 364 england leidy cyl hippolyte
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 365 road ridge hundred
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 366 soft effect made magnetism electro long
 limestone dip west schist east north south fault mica region eastern beds mountain gneiss
 367 area side quartzite strike western map
 salt water salts brine found mother neutral crystallization liquor evaporation barium saline
 368 pure common lost anhydrous dry works phthalate fresh
 aod io tbe oo ao washed accent oot hartz qts ooe note uk pine vowel quintals terminations
 369 marine ine pin
 atoms molecule compounds atom molecules carbon hydrogen group structure formula
 370 compound groups molecular form oxygen nitrogen position double organic positions
 leaves leaf stem structure cells tissue plant root stems developed roots epidermis bundles
 371 observed thin growth branches parenchyma section wood
 potential electrode cell electromotive force electrodes cells hydrogen 1 volt solution
 372 measurements concentration potentials solutions chloride ion calomel liquid normal
 survey geological report geology state pp map maps states united work annual geologist
 373 reports part region mineral surveys plates field

gram grams cent gave found weight cc calculated substance liter cubic results water
 374 experiment weighed hours centimeters amount obtained dissolved
 tungsten vanadium molybdenum reduction tungstic trioxide molybdate oxide molybdic
 375 tungstate uranium chromium vanadic vanadate bismuth zinc mo reductor separation oxides
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 377 370 395 400 390 380 365 375 360 357 355 366 373 368 356 353 392 393 354 371 358
 378 15 14 13 16 18 17 12 19 20 11 10 21 9 22 8 7 6 23 24 ii
 pounds pound cents foot square 1 kilos grains gallons cubic yield lbs bushel xanthogallol
 379 equivalent theurer 100 4 ounce charge
 boiling liquid point distillation distillate fraction mixture distilled fractions points liquids
 380 volatile obtained fractional temperature mm retort vapor distilling composition
 meters ball meter balls cubic balloon kilograms glower kilometers caryophyllin centi
 381 centimeters kilogram urson comparisons balloons kilometer comparator made millimeters
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 382 names grows linn woods havana met
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 388 set testing magnesia raw tensile tests sand
 acids acid fatty stearic oleic salts fat number uric soluble insoluble unsaturated saponification
 389 oxidation iodine free fats melting lead palmitic
 teeth lower molar jaw tooth upper species molars posterior marsh length size anterior genus
 390 diameter specimen type premolar crown canine
 sodium chloride calcium potassium barium sulphate magnesium carbonate hydroxide
 391 ammonium salts salt solution nitrate strontium solutions lithium water alkali chlorides
 gold silver metals metal assay ounces auric auriferous ton precious au metallic mines rich fine
 392 coin assays quicksilver button leaf
 system systems general metric number ternary binary relations relative type scheme sys
 393 arranged model common study tem fundamental base continuous
 394 ci cl ct pr cr c1 1 recom gl cj mended c2 ii cs hc1 fp ca kci c3 ru
 oxide earths cerium rare yttrium thorium zirconium oxalate titanium oxides separation
 395 lanthanum acid fractions earth columbium tantalum obtained neodymium nitrate
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 396 wells supplied experiment clear croton reservoir
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 408 obtained printed bttm journal wt ht
 ether alcohol water solution acid mixture obtained sodium distilled residue extracted hours
 409 added oil product dried chloride grams dissolved bath
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 413 0 1 table 05 01 30 vi 001 vii 025 8o ix min 050 295 2o 495 099 094 035
 414 ot ir ar war har ro thir hir mi itr tor ard beer tt ret ruch gar io ur nt
 brown white color black dark yellow light green red gray colored yellowish reddish pale
 415 greenish brownish blue deep darker spots
 work chemist laboratory technical chemists experience years large works care position young
 416 good engineering laboratories analytical man chemistry training men
 time hours minutes days hour day period rate half end twenty minute ten temperature
 417 experiment seconds allowed 24 intervals longer
 gas hydrogen gases oxygen air nitrogen volume water carbonic carbon pressure mixture
 418 acetylene gaseous volumes evolved oxide absorption apparatus atmosphere
 coral islands reef reefs island corals barrier sea subsidence lagoon pacific group ocean growth
 419 dana atolls atoll depth elevated rock
 years professor school college science age year work university life died time scientific death
 420 study chemistry education students early schools
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 421 slack currente middle york ands
 pressure vapor temperature pressures liquid temperatures mm water mercury density high
 422 tem volume point atmospheres dissociation atmospheric tension viscosity partial
 urine nitrogen urea day period uric creatinine days excretion total diet fast daily grams feces
 423 output average subject ammonia body
 optical refraction angle light plane parallel index refractive extinction optic polarized crystal
 424 axis plate polarization angles section axes indices 1
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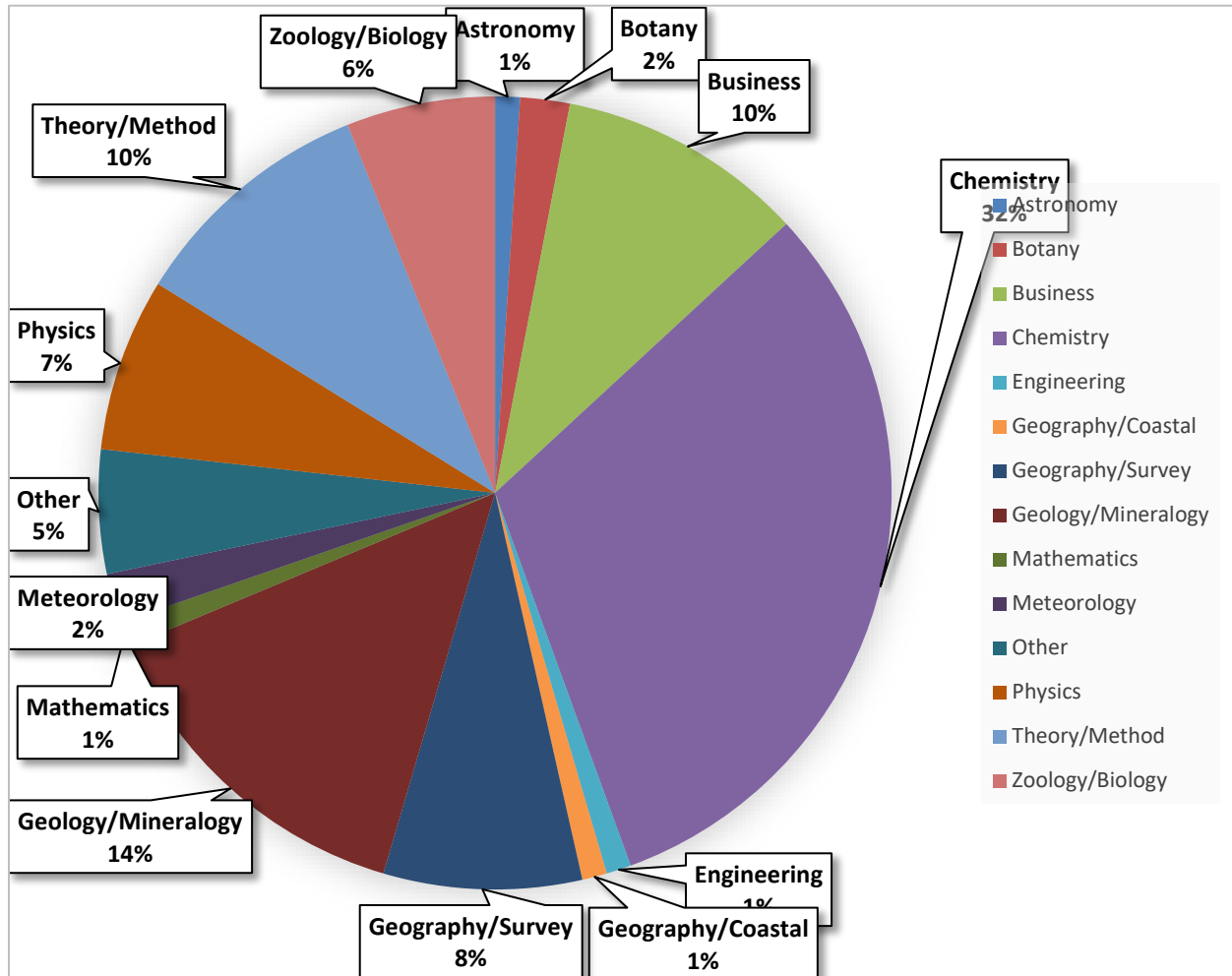
1 journal chem ibid 1910 1912 1908 1911 1913 1909 soc 1907 1914 1915 physik 1906 1916
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 427 mol mols 1 suc fraction 2 cacl cdl n2 cessive bacl 1000 cc cdcl srcl 3 lusca naci py cone
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 429 experiments concentrated salt solu saturated strength sodium found tion dilution
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 430 parasites mosses lichens sexual parasitic bodies sporangia host
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 433 orientate tennessee oo7812 ooi953 hetero 1t
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 434 materials efficiency act purposes building designed conditions constructed
 trees tree wood forest water soil country vegetation found ground forests large growth land
 435 covered dry leaves earth great surface
 electricity current electric electrical battery discharge spark wire conductor experiments
 436 galvanic induction action electro machine circuit produced metallic contact apparatus
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 437 manufacture dollars large business products government market
 current anode cathode solution platinum electrolysis electrolytic electrolyte deposit metal
 438 copper deposited volts cell electrodes amperes electrode cadmium silver time
 sulfur cellulose fiber dioxide pentosans arsphenamine furfural 1 material crude soluble kg
 439 fibers carbohydrates content toxicity trioxide reduction products nitro
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 440 1888 1891 1892
 alcohol soluble water acid solution melting crystals ether found obtained needles compound
 441 yellow acetic substance calculated insoluble product hot benzene
 parts part million loss half divided gain contained original hundred present giving lost gave
 442 table showing stated amounts including greater
 weight atomic weights molecular determinations elements series ratio element values
 443 determined number mass isotopes table density determination chlorine clarke data
 clock time telegraph circuit signals signal line made wires survey wire station pendulum
 444 stations cable coast seconds miles record register
 life development animals plants forms animal species growth living evolution individual
 445 organic nature origin conditions vegetable form natural generation plant
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 457 respiration juice muscular muscle vessels physiological
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 458 development system types families animal relations characters family
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 489 photosphere surface contact earth disc radiation terrestrial total planet
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 498 succession sets ii higher shown successive 8 recovery beginning
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Appendix X

Visualization of Categories for Topic Model of All Journals Utilizing Documents of 1,000 Words, 1818 - 1922



Appendix XI

Word List and Rates per 1000 for Business and Method Related Words in the *Journal of the American Chemical Society*

Word	Rate per 1000 Pre1892	Rate per 1000 1892- 1903
Method	1.751189667	2.022492128
author	1.042828008	0.398560504
results	1.284840245	2.010346379
analysis	1.061862678	1.087044534
preparation	0.415363698	0.441745389
action	1.772943576	0.981106613
apparatus	1.211420802	0.618083671
paper	0.846363018	0.724021592
society	0.589394969	0.510346379
foreign	0.208701564	0.070175439
leeds	0.290278722	0.017094017
read	0.354180829	0.32928475
charles	0.147518695	0.281826361
table	0.345343304	0.626180837
employed	0.346023114	0.305668016
news	0.191706322	0.078272605
product	0.472467709	0.456140351
examination	0.386811693	0.224021592
schuylkill	0.068660775	0.000224921
city	0.306594154	0.317813765
york	0.382732835	0.425775978
committee	0.284160435	0.335807467
falsification	0.002719239	0.000449843
philadelphia	0.23589395	0.152271705
theory	0.159755269	0.269905533
discovery	0.048946295	0.05465587
general	0.422841604	0.479307242
chicago	0.059823249	0.201304543
london	0.197824609	0.114260009
joseph	0.065941536	0.080521817

thomas	0.110129164	0.200179937
edward	0.063222298	0.143949618
university	0.174711081	0.262483131
published	0.143439837	0.197705803
james	0.166553365	0.119208277
paris	0.220258328	0.152271705
boston	0.091094494	0.157219973
ohio	0.056424201	0.118758435
brooklyn	0.175390891	0.107512371
carl	0.03942896	0.034188034
congress	0.004758668	0.126630679
laboratory	0.173351462	0.442645074
journal	0.339225017	0.367521368
error	0.171991842	0.295546559
chemists	0.174031271	0.383040936
work	0.267165194	1.051731894
tests	0.178110129	0.270580297
order	0.346023114	0.412955466
year	0.184228416	0.279577148
samples	0.334466349	0.454790823
series	0.468388851	0.486279802
fact	0.385452073	0.4365722
professor	0.031271244	0.19005848
american	0.737593474	0.614035088
section	0.080217539	0.468511021
secretary	0.197824609	0.200854701
meeting	0.497620666	0.363247863
elect	0.002719239	0.004273504
president	0.101971448	0.165092218
study	0.179469748	0.352001799
research	0.063222298	0.258434548
germany	0.07885792	0.212325686
determination	0.771583956	0.826135852
subject	0.203263086	0.327260459
process	1.728076139	0.709626631
report	0.322229776	0.347728295
washington	0.099932019	0.217049033
book	0.014276003	0.290373369
equation	0.125764786	0.114709852
data	0.128484024	0.238866397
smith	0.134602311	0.212550607
review	0.055744392	0.303643725

chair

0.129843644

0.046333783

Curriculum Vitae

SHAWN MARTIN

Baker-Berry Library
Dartmouth College
6025 Baker-Berry Library
Hanover, NH 03755

E-mail: Shawn.J.Martin@Dartmouth.edu
Web: <http://www.shawnmartin.net>

EDUCATION

Indiana University, School of Informatics, Computing, and Engineering,
Bloomington, IN

Degree: Ph.D. – Major: Information Science – June 2019

Minor: History and Philosophy of Science and Medicine

Certificate – Digital Humanities

University of Pennsylvania, Wharton School of Business, Philadelphia, PA
Certificate – Business Essentials – 2013

University of Maryland University College, Center for Intellectual Property,
Adelphi, MD

Certificate – Copyright Leadership and Management – 2009

College of William and Mary, School of Arts & Sciences, Williamsburg, VA
Degree: M.A. – History – 2000

Ohio State University, College of Arts & Sciences, Columbus, OH

Degree: B.A. – Major: History – 1999

Minor: Theatre

Summa cum Laude with Honors in the Liberal Arts and
with Distinction in History

EMPLOYMENT

Dartmouth College – Baker-Berry Library – Hanover, NH

Head of Scholarly Communication, Copyright, and Publishing – March
2019 – Present

Led and coordinated the library's scholarly communication,
copyright, and publishing program activities across campus
including Dartmouth's institutional repository and the creation of
digital collections and broader publication initiatives at the
College.

Indiana University – School of Informatics, Computing and Engineering
Bloomington, IN

*Integrated Doctoral Education with Application to Scholarly
Communication (IDEASc) Fellow – August 2015 – March 2019*

Part of a cohort of fellows funded by the Institute for Museum
and Library Services (IMLS) to further scholarship and practice
in the area of scholarly communication.

University of Pennsylvania – Van Pelt Library – Philadelphia, PA

Scholarly Communication Librarian – April 2008 – July 2015

Directed all scholarly communication initiatives at the
University of Pennsylvania Libraries including advising on
intellectual property, managing the institutional repository, and
helping facilitate both internal and collaborative projects for
scholarly publishing and digital scholarship.

University of Michigan – Hatcher Graduate Library – Ann Arbor, Michigan

Project Librarian – January 2003 – April 2008

Managed all outreach, development, and administration of the
Text Creation Partnership project (a cooperative effort with three
scholarly publishers and over one hundred libraries around the
world to create public domain SGML/XML encoded texts for e-
published image collections).

Ohio Historical Society - Archives/Library – Columbus, Ohio

Digitization Specialist – September 2000 – December 2002

Handled digitization process of manuscripts, photographs,
museum objects, and other materials for the Ohio Memory Project
(a collaborative project similar to the American Memory Project
at the Library of Congress).

**OTHER
EXPERIENCE**

Indiana University – Bloomington, IN

School of Informatics, Computing and Engineering

Associate Instructor – August 2018 – March 2019

Worked with incoming doctoral students and assisted with
revision of doctoral program manual, preparation, research, and
teaching for three courses: digital curation, digital repositories,
and information institutions.

Teaching Assistant – August 2017 – December 2017

Assisted with teaching, grading, and planning for courses on user
services and tools.

*Research Assistant – Comic Book Readership Archive (CoBRA) – August
2015 – August 2017*

Performed research, programming, and analysis for a digital
humanities project of primary source material and related
datasets documenting American comic book readership and
fandom. (<http://www.indiana.edu/~comics/cobra/>)

Wells Library

Copyright Researcher – Media Digitization and Preservation Initiative (MDPI) – August 2015 – February 2019

Researched copyright status of films, songs, and other media for inclusion in Indiana University's digitization initiative containing over 250,000 rare and deteriorating audio-visual materials.

Open Access Consultant – Department of Scholarly Communication – August 2015 – November 2016

Helped create open access policy for university, trained faculty and staff on issues related to open access and assisted with implementation of policy and other open scholarship initiatives at Indiana University.

Wylie House Museum

Project Manager – Leadership at Indiana University: Andrew and Theophilus Wylie, 1820-1890 – August 2017 – May 2018

Supervised all aspects for grant funded public history project from Indiana University's Office of the Bicentennial (<http://collections.libraries.indiana.edu/wyliehouse/leadership>). My duties included the management of student and volunteer positions, creation of learning modules, and design of website.

Drexel University – College of Computing and Informatics – Philadelphia, PA
Adjunct Faculty – June 2011 – January 2015

Taught classes on digital libraries and the history of the book to graduate students in the information and library science program.

Council on Library and Information Resources – Washington, D.C.

Intern – March 2005

Helped the President with researching and outlining speech topics, writing summary reports of policy issues, and developing scholarly communication and strategic planning initiatives.

Indiana University – Purdue University Indianapolis - School of Library and Information Science – Indianapolis, IN

Teaching Assistant – January – June 2002

Taught classes on digital libraries and digital library technology.

The Colonial Williamsburg Foundation - Department of Historical Research – Williamsburg, Virginia

Intern Fellow – September 1999- July 2000

Assisted with production and coordination of the Digital Library Project at the John D. Rockefeller Jr. Library at the Colonial Williamsburg Foundation.

Ohio State University - University Technology Services - Columbus, Ohio
Training Coordinator - 1998-1999

Responsible for teaching classes on Information Technology, programming and maintaining a database for the public, computing sites, and coordinating customer service initiatives within University Technology Services.

Site Supervisor - 1996-1998

Responsible for management and administration of public computer labs at University Technology Services.

Site Assistant - 1995-1996

Responsible for answering questions about software, hardware and other general questions and customer services at the public computer labs at University Technology Services.

PUBLICATIONS

Book Chapters:

“Early Indiana Presidents: Incorporating Digital Humanities, Public History, and Community Engagement” Co-authored with Carey Beam. *Quick Hits: Teaching with Digital Humanities* (Indiana University Press, Forthcoming 2019).

“‘The Spider’s Web’: An Analysis of Fan Mail from *Amazing Spider-Man*, 1963–1995” Co-authored with John Walsh and Jennifer St. Germain. *Empirical Approaches to Comics Research* (Routledge, 2018).

“Research Management: The Next Step for Open Access” *Open Access and the Impact on Library Services* (Rowman & Littlefield, 2016).

“Images, Texts, and Records: Electronic Teaching in a Confusing Landscape.” *Teaching Early Modern Literature from the Archive*. (Modern Language Association, 2015).

“A Modest Proposal for Scholarly Publishing: 21st Century Ideas for a 19th Century System” *New Technologies in Medieval and Renaissance Studies* (Iter/Arizona Centre for Medieval and Renaissance Studies, 2015).

“Providing a Base for E-Editing: The Text Creation Partnership Project” *New Ways of Looking at Old Texts* (Renaissance English Text Society, 2014).

“[Open Access and Digital Libraries: a Case Study of the Text Creation Partnership](#)” *Electronic Publishing: Politics and Pragmatics*. (Iter/Arizona Centre for Medieval and Renaissance Studies, 2010).

“A Universal Humanities Digital Library: Pipe Dream or Prospective Future?” *Digital Scholarship*, ed. Marta Deyrup (Routledge, 2009).

Peer-reviewed

Journal Articles:

“A Tale of Two Models: Theophilus A. Wylie and Higher Education in Nineteenth-Century Indiana” *Indiana Magazine of History* (March 2019).

“[Networking Social Knowledge. . . Again.](#)” *KULA: Knowledge Creation, Dissemination, and Preservation Studies*. (February, 2019).

“[Historicizing the Knowledge Commons: Open Access, Technical Knowledge, and the Industrial Application of Science.](#)” *KULA: Knowledge Creation, Dissemination, and Preservation Studies*. (February, 2019).

["Understanding Perspectives on Sharing Neutron Data at Oak Ridge National Laboratory."](#)co-authored with Devan Donaldson and Thomas Proffen. *Data Science Journal.*, (vol. 16, 2017).

["Research Management: Combining Platforms, Practices, and Policies."](#) *Journal of Electronic Publishing* (vol. 20, no. 2, 2017).

"To Google or not to Google, that is the question: Supplementing Google Books to make it more useful for scholarship." *Journal of Library Administration* (Haworth Press, Volume: 47 Issue: 1/2 September, 2008).

["Bringing Text Alive: The Future of Scholarship, Pedagogy, and Electronic Publication."](#) *Early Modern Literary Studies*, Special Edition, editor. September, 2008.

["Digital Scholarship and Cyberinfrastructure in the Humanities: Lessons from the Text Creation Partnership"](#) *Journal of Electronic Publishing*. Volume 10, No. 1 (January, 2007).

["EEBO, Microfilm, and Umberto Eco: Historical Lessons and Future Directions for Building Electronic Collections"](#) *Microform & Imaging Review* (Volume 36, No. 4, Autumn 2007).

["Collaboration in Electronic Scholarly Communication: New Possibilities for Old Books"](#) *Journal of the Association for History and Computing*. Volume IX, No. 2 (October, 2006).

Proceedings:

["Science Serving Industry: Documentary Authority and Industrial Influence in 19th Century American Chemistry"](#) *Proceedings of the Document Academy* (December, 2017).

["Textual Analysis and the History of Scholarly Communication."](#) *Proceedings of the Association for Information Science and Technology* (October, 2017)

["Using Digital Content to Provide Students With Virtual Experiences in an Online History of the Book Course"](#) (co-authored with Lisl Zach) *Edulearn Proceedings* (June 2014).

["Reaching Out: What Do Scholars Want from Electronic Resources."](#) *Proceedings of the Association for Computing in the Humanities/Association for Literary and Linguistic Computing*, 2005.

"The Conscience of the King:" A Comparative Study of English and Burgundian Courtly Spectacle. In Robert D. Yearout, ed. *Proceedings: National Conference for Undergraduate Research*. Vol. I. The University of North Carolina, Asheville, 1999.

Reviews:

Empire Online Microform & Imaging Review (May 2007).

Other Articles:

["Balancing influence in a shifting scholarly communication landscape: Creating library-owned, community-aligned infrastructure through individual, local, and](#)

[community action](#)” (co-authored with Sarah Wipperman and Chealsye Bowley) *College and Research Libraries News* (May, 2018).

[“The Age of Erasable Books”](#) *The Atlantic* (July 9, 2014) .

[“Limelight Arts: Applying A Holistic Approach to Arts Education”](#) (co-authored with LaShawn Anthony) *Philadelphia Social Innovations Journal* (Issue 12, Winter, 2012).

[“Cultural Data Project: Measuring the Impact of the Arts”](#) (co-authored with Rebecca McElroy) *Philadelphia Social Innovations Journal* (Issue 10, Spring 2012).

[“Building Business Models to Last: Digital Resources Beyond 2010”](#) *CLIR Issues* (Number 72 November/December 2009).

“Early English Books Online – Text Creation Partnership, or EEBO: The Next Generation” *JISC Collections* (December, 2007).

“Anglo French Wars”. *Great Events in History: 1454-1600*. Salem Press, 2005.

“Early English Books Selection: Bridging the Gap.” *BiblioNotes*, Autumn 2003.

**PEER
REVIEWED
PRESENTATIONS**

Topic Modeling and Textual Analysis of American Scientific Journals, 1818 – 1922, Association for Computing in the Humanities, Pittsburgh, PA, June, 2019.

The Power of Science: Origins of American Scholarly Communication, 1840 – 1900, IConference Doctoral Colloquium, Washington, DC, April, 2019.

Topic Modeling and Textual Analysis of American Scientific Journals, 1818 – 1922, Current Research in Digital History, Fairfax, VA, March, 2019.

The 2.5% Commitment: 2.5% of Whom?, Academic Libraries of Indiana Scholarly Communication Librarianship Conference, Indianapolis, IN, October, 2018.

Mediating Professional Scholarship. . . Again: Professionalization of Science and the Creation of Nineteenth-century Academic Journals Books, Publishing, and Libraries, Philadelphia, PA, July, 2018.

One Hundred Years of American Science : Topic Modeling of Scientific Journals in Hathi-Trust Hathi-Trust Research Center Uncamp, Berkeley, CA, January, 2018

Networking Social Scholarship . . . Again at Beyond Open: Implementing Social Scholarship, Victoria, Canada, January, 2018

Textual Analysis and the History of Scholarly Communication at the Association for Information Science and Technology (ASIS&T), Crystal City, VA, October, 2017

Science Serving Industry: Documentary Authority and Industrial Influence in 19th Century American Chemistry at the Document Academy, Bloomington, IN, September, 2017

A Tale of Two Chemists: Academic Journals and the Technology of Science Communication at Society for the History of Authorship, Reading, and Publishing (SHARP), Victoria, Canada, June, 2017.

"Spins A Web Any Size": Topic Modeling a Corpus of American Comic Book Fan Mail (co-authored with John Walsh and Jennifer St. Germain) at The Empirical Study of Comics, Bremen, Germany, February, 2017.

Understanding Perspectives on Sharing Neutron Data at Oak Ridge National Laboratory (co-authored with Devan Donaldson) at the Research Data Alliance 8th Plenary Meeting, Denver, CO, September, 2016.

Growing the Vision: Next Steps for Library Open Access Publishing at the International Library Federation Section on Acquisition and Collection Development Satellite Meeting, Ann Arbor, MI, August, 2016.

Scholarly Communication Institutions: Transforming Scholarship with History at the Society for Social Studies of Science (4S), Denver, CO, November, 2015

The Future of Digital Scholarship: Current Trends and Upcoming Needs for Scholarly Communication at Advancing Research Communication and Scholarship, Philadelphia, PA, April, 2015

Using Digital Content to Provide Students with Virtual Experiences in an Online History of the Book Course At Edulearn, Barcelona, Spain, July, 2014.

Moving 'The History of the Book' into the 21st Century at Drexel University Showcase on Teaching, March, 2014

Fair Use, Intellectual Property, and New Media at American Library Association, Anaheim, CA, June 2012

The Digital History Seminar at American Historical Association, Chicago, IL, January 2012

Open Access: Promoting University Goals at Berlin 9 Conference, Washington, DC, November 2011

Training Students for the Help Desk at Educause, Philadelphia, PA, October, 2011

From Education to Preservation: Emerging institutional repository services in the scholarship lifecycle at American Society for Information Science and Technology (ASIS&T), Pittsburgh, PA, October 2010

University Publishing Consultants at the American Association of University Presses Meeting (AAUP), Philadelphia, PA, June 2009

Institutional Repository Personality Disorder: How do we cure it? At the Scholarly Publishing and Academic Resources Coalition (SPARC) Digital Repositories Meeting, Baltimore, MD, November, 2008

Beyond Corpora: Some thoughts on TCP as a model for creation of even more collections At the Renaissance Society of America, Chicago, IL, April 2008

Making History Public in an Age of Closed Access At the American Association for History and Computing, Providence, RI, 2007

Changing Libraries and Scholars in the Digital Age: The Text Creation Partnership At the American Literature Association, Boston, MA, 2007

Models For Creating Large, Sustainable Digital Collections: The Text Creation Partnership At the Million Books Symposium, Boston, MA, 2007

Electronic Scholarship in Early American Studies At the Society for Early Americanists, Williamsburg, VA, 2007

A Universal Text Editing Project: Pipe Dream or Prospective Future? At the Society for Textual Scholarship, New York, NY, 2007

Closed Access/Open Access: Hybrid Models at the Renaissance Society of America, Miami, FL, 2007

A New Collaborative Model: Scholars, Librarians, Publishers working to create digital libraries At the Association for College and Research Libraries, Baltimore, MD, 2007

Teaching Early American Literature with Texts and Images at the American Literature Association, San Francisco, CA, 2006

A Usage Paradox: Electronic Resources, Merging Roles, and Collaborative Projects at the American Association for History and Computing Online Conference, 2006

Using Electronic Resources in Scholarship and Teaching at the American Society for Eighteenth Century Studies, Montreal, Canada, 2006.

Electronic Publishing in Renaissance Studies at the Renaissance Society of America, San Francisco, CA, 2006

Use of Electronic Resources for Scholarship and Pedagogy At the American Historical Association, Philadelphia, PA, 2006

Text Creation and the Future of Electronic Resources At the American Association for History and Computing, Chicago, IL, 2005

Reaching Out: What do scholars want from electronic resources? At the Association for Computing in the Humanities/Association for Literary and Linguistic Computing, Victoria, Canada, 2005

Navigating Electronic Contexts At the Society for the History of Authorship, Reading, and Publishing, Dalhousie, Canada, 2005

Corpus Inter Corpora At the American Association of Applied Corpus Linguistics / International Computer Archive of Modern and Medieval English Joint Conference, Ann Arbor, MI 2005

New Textual Scholarship: From Consumer to Producer At the Society for Textual Scholarship, New York, NY, 2005

"Waking Up in the British Library." At the American Historical Association, Seattle, WA, 2005

Textual Patterns in Medieval and Early Modern English Literature. At the International Congress on Medieval Studies, Kalamazoo, MI 2005

The Future of Electronic Resources? At the Renaissance Society of America, Cambridge, UK, 2005

A New Collaborative Model: Scholars, Librarians, Publishers and the Creation of Electronic Resources with Andrew Kuster At the Association for College and Research Libraries, Minneapolis, MN, 2005

Digital Preservation and Electronic Scholarly Editions. At the Modern Language Association, Philadelphia, PA 2004.

A New Cooperative Model: Scholars, Librarians, Publishers, and the Production of Electronic Resources. At the Association for Computing in the Humanities/Association for Literary and Linguistic Computing, Gothenburg, Sweden, 2004

A New Model for Private/Public Cooperation. At the Renaissance Society of America Conference, New York, NY, 2004

Electronic Resources and Scholarly Publishing. At the Renaissance Society of America Conference, Toronto, ON, Canada, 2003.

"The Conscience of the King:" A Comparative Study of English and Burgundian Courtly Spectacle. At the National Conference for Undergraduate Research, Rochester, NY, 1999

"The Conscience of the King:" A Comparative Study of English and Burgundian Courtly Spectacle. Ohio State University College of the Humanities Research Colloquium, Columbus, OH, 1999

**INVITED
PRESENTATIONS**

Topic Modeling and Textual Analysis of American Scientific Journals, 1818 – 1922, Doctoral Research Forum, October, 2018.

Leadership at Indiana University: Andrew and Theophilus Wylie, 1820 – 1890. Humanities, Arts, Science and Technology Alliance and Collaboratory (HASTAC) and Indiana Digital Arts and Humanities (IDAH) Symposium, September, 2018.

Why Do We Communicate Scholarship?, Association of College and Research Libraries (ACRL)/Scholarly Publishing and Academic Resources Coalition (SPARC) Forum, American Library Association (ALA) Midwinter Conference, February, 2018.

Affordances of Documentary Authenticity for Scholarly Communication, Doctoral Research Forum, October, 2017

A Tale of Two Chemists: J. Lawrence Smith, Theophilus Wylie, and the Communication of Science, Doctoral Research Forum, October, 2016

Research, Teaching, and Service Activities: From Doctoral Student to Faculty Member, Doctoral Research Forum, March, 2016

Current Trends in Scholarly Communication, ARL Leadership Institute, January, 2014

Peer Review, History Journals, and the Future of Scholarly Research at the American Historical Association, January, 2013

A Forum for Publishers and Librarians at the Society for Scholarly Publishing, Washington, DC, February 2011

What's Next? Patterns and Practices in History in Print and Online, American Historical Association, Boston, MA, January 2011

Critical Issues in Bibliography and Libraries in the Digital Age, American Historical Association, Boston, MA, January 2011

Images, Texts, and Records: Tools for Teaching in a Confusing Landscape at Beyond the Facsimile: Rich Models of Late Medieval and Early Modern Texts Symposium, Sheffield, UK, December 2010

Digital Humanities: Libraries and Repositories Transforming Scholarly Communication and Publishing Forum, University at Buffalo, Buffalo, NY, March 2010.

Promises and Perils of Electronic Theses and Dissertations, Carnegie Mellon University, Pittsburgh, PA February 2010.

Is Google Good for History? at the American Historical Association, San Diego, CA, January, 2010

Electronic Theses and Dissertations, American Library Association Midwinter Meeting, Boston, MA January, 2010.

Launching and Growing the ScholarlyCommons@Penn: Putting Knowledge to Work: Building an Institutional Repository for Your Campus, San Luis-Obispo, CA, October, 2008

Text Creation Partnership Project Update: American Library Association Midwinter Meeting, Philadelphia, PA, January 2008

Darth Vader, Open Access, and Digital Libraries: What is the Future of Electronic Collections?: David Binkley Paper on Emerging Technology, Access 2007 Conference, Victoria, Canada, 2007.

Text Creation Partnership Project Update: American Library Association Annual Meeting, Washington, DC, 2007.

Text Creation Partnership (TCP): The Future of Electronic Resources? Western European Studies Section, American Library Association Midwinter Meeting, Seattle, WA, 2007.

Text Creation Partnership Project Update: American Library Association Midwinter Meeting, Seattle, WA, 2007.

Collaboration in Digital Projects: The Text Creation Partnership – Models of Partnership in Digital Research, University of Sheffield, Humanities Research Institute, December, 2006

New Textual Scholarship: From Consumer to Producer Human Computer Interaction – Book Working Group, Victoria, BC, Canada, October, 2006

Are Libraries Dead? The Internet and the Future of Information Detroit Association of Phi Beta Kappa, Detroit, MI, May, 2006

The Impact of Online Resources on Scholarship and Academic Libraries. Librarians' Forum, University of Michigan Library, Ann Arbor, MI, April, 2006.

Text Creation Partnership Project Update: American Library Association Annual Meeting, New Orleans, LA, 2006.

Text Creation Partnership Project Update: American Library Association Midwinter Meeting, San Antonio, TX, 2006.

Finding Buried Treasure in Large Digital Collections Digital Dissertation Series, University of Michigan Library, Ann Arbor, MI, September 2005

Collaboration and Communication in Building Electronic Resources At (De)materializing the Early Modern Text Symposium Bath Spa University College, Bath, UK, 2005

Old and Rare Books Online: Enriching Scholarship Series, University Library, Ann Arbor, MI, 2005

Collaboration in the Development of Romance Language Digital Resources: Western European Studies Section, American Library Association Annual Meeting, Chicago, IL, 2005

Text Creation Partnership Project Update: American Library Association Annual Meeting, Chicago, IL, 2005

Text Creation Partnership Project Update: American Library Association Midwinter Meeting, Boston, MA, 2005

Electronic Text Creation for Primary Resources: University of Michigan Library exchange for visitors from Tianjin, China, Ann Arbor, MI, April, 2004

Electronic Resources in Graduate Studies: Teaching Technology at the University Library, Ann Arbor, MI, 2004

Electronic Text Creation for Primary Resources: University of Michigan Library exchange for visitors from Tianjin, China, Ann Arbor, MI, January, 2004

Text Creation Partnership Project Update: American Library Association Annual Meeting, Orlando, FL, 2004

Electronic Resources and Scholarly Publishing: E-Text Centers Discussion Group, American Library Association Annual Meeting, Orlando, FL 2004

Digitization and Electronic Resources: Boston Library Consortium, Boston, MA, May 2004

Science in the Internet. At the History of Science Society, Cambridge, MA, November 2003

Teaching with Technology: Digital Dissertation Series, University of Michigan Library, Ann Arbor, MI, September 2003

Text Creation Partnership Project Update: American Library Association Annual Meeting, Toronto, ON, Canada, 2003

Text Creation Partnership Project Update: American Library Association Midwinter Meeting, Philadelphia, PA, 2003.

TEACHING

Digital History

Taught modules on website development for a course exploring history with digital tools like text mining, network analysis, spatial history and makerspace technology.

Digital Humanities

Taught modules on topic modeling for a course introducing the use of information technology in literary and humanistic study including

electronic editing, computational analysis of big data, and the cultural impact of information technology on society.

Digital Libraries

Taught modules on digitization, production, and project management for courses covering the theory and practice of online collections and exhibits in both academic and community settings.

History of the Book

Primary instructor for a course that examined the history of written knowledge representation through manuscripts, books, digital media, and other forms in western culture, from the classical age to the present day.

User Services and Tools

Taught modules on copyright and digital libraries for course introducing students to basic information sources and services among different types of libraries and information centers, including academic, public, special, and school media.

HONORS

Doctoral Research Forum – Best Paper (1st Place, 2018)
Doctoral Research Forum – Best Paper (2nd place, 2017)
VuStuff Award – Villanova University (2010)
Phi Beta Kappa
Phi Kappa Phi
Phi Alpha Theta
Dean's List - College of the Humanities, The Ohio State University
(all quarters 1995-1999)
Honor Roll – St. Charles Preparatory School (all years 1991 – 1995)
Best Performer – Davis Discovery Center production of “Listen with your Heart”
– 1992
Boston University Book Award – St. Charles Preparatory School – 1994
National Honor Society – St. Charles Preparatory School – 1992
Eagle Scout – 1990

**SCHOLARSHIPS,
FELLOWSHIPS
AND GRANTS**

Project Grant – Indiana University Bicentennial – 2017 - 2018
PhD Travel Award – Department of Information and Library Science, School of Informatics and Computing, Indiana University - 2017
Digital Humanities Summer Institute (DHSI) Scholarship – University of Victoria - 2017
Integrated Doctoral Education with Application to Scholarly Communication (IDEASc) Fellowship – Institute for Museum and Library Services – 2015 - 2019
Meeting Support Grant – Gladys Kreble Delmas Foundation – 2009
Meeting Support Grant – Council on Library and Information Resources – 2009
Conference Support Grant – Gladys Kreble Delmas Foundation - 2005
Scarlet and Gray Scholarship - The Ohio State University - 1997
Undergraduate Research Scholarship - The Ohio State University - 1999
“In the Know” Scholarship – The Ohio State University-1995

Faculty Scholarship – The Ohio State University – 1995
Conference Grant - The College of the Humanities, The Ohio State University-
1999 to:
The National Conference on Undergraduate Research,
University of Rochester, Rochester, NY

PROFESSIONAL ACTIVITIES

Baker-Berry Library, Dartmouth College

Open Dartmouth Working Group – Chair – 2019 – Present

Association for Information Science and Technology (ASIS&T)

*Special Interest Group – History and Foundations of Information
Science*

Secretary – 2017 – 2018

Wells Library, Indiana University

Bloomington Faculty Council Library Committee – Member – 2016 –
2017

Digital Humanities Now

Editor-at-large – 2016 - 2018

Van Pelt Library, University of Pennsylvania

Coursera Implementation Team – Member- 2012 – 2014

Repository Services Team – 2011 – 2015

Librarians' Assembly – Secretary – 2009

*Scholarly*Commons Steering Committee – Chair – 2008 – 2011

Scholarly Communication Website Task Force – Chair – 2008

Data Set Task Force – Member – 2008 – 2014

Electronic Dissertation Task Force – Member – 2008 – 2009

PennPages Directory Structure Task Force – Member – 2008

University Library, University of Michigan

Electronic Resources Committee – Member – 2005 – 2008

Staff Travel Committee – Member – 2005 – 2006

Committee Service Task Force - Member – 2005 - 2006

Web Management Committee - Member – 2004 – 2008

Humanities Electronic Resources Team – Member – 2003 – 2008

Nicely Collection Processing Team – Coordinator – 2003 - 2008

ProQuest

Dissertations and Theses Advisory Board – Member – 2014 - 2016

Journal of Librarianship and Scholarly Communication

Editorial Board – Member – 2011 – 2014

American Library Association – Association of College and Research Libraries (ACRL)

ACRL Scholarly Communications Committee

Member – 2010 – 2012

ACRL 2011 Program Sub-Committee – Member – 2010

Literatures in English Section

Secretary – 2008 – 2009

Webmaster – 2006 – 2008

Executive Committee – Member - 2006 – 2009, 2011 – 2012

2012 Program Committee – Chair – 2011 – 2012

Publications Committee – Member - 2006 – 2008

Nominating Committee – Chair – 2007 - 2008

Western European Studies Section

Member-at-Large – 2009 – 2010

Executive Committee – 2007 – 2008, 2009 – 2010

Publications Committee – Chair – 2007 – 2008

– Member – 2006 – 2007

NEH Digital Humanities Start-Up Grant Review Panel

Member – 2012

American Association for History and Computing

Executive Director – 2008 – 2015

Society for the History of Authorship, Reading, and Publishing (SHARP)

Program Committee 2013 Conference – Member – 2012 – 2013

The Republic of Letters: Science & Learning - Renaissance to Enlightenment, University of Florida

Advisory Board – Member – 2009 - Present

Implementing New Knowledge Environments (INKE) – Humanities Computing and Media Centre, University of Victoria

Member – 2006 – present

Journal of the Association for History and Computing

Interim Executive Editor – 2009 - 2010

Editorial Board – 2007 – 2013

VUStuff II Conference

Awards Committee – Member – 2011

THATCamp – Philly

Organizing Committee – Member – 2011

Electronic Ballad Archive - Early Modern Center, University of California – Santa Barbara

Advisory Board – Member - 2003 – 2008

Digital Renaissance Editions Project – University of Western Australia

Advisory Board – Member - 2006 – 2008

College of William and Mary – Williamsburg, VA

Library Advisory Committee - Member - 1999 – 2000

OTHER ACTIVITIES

Young Friends – Philadelphia Museum of Art – Philadelphia, PA

Board – Member – 2011 – 2015

Membership and Outreach Committee – Member – 2011 – 2013

2013 Fall Into Art Fundraiser – Co-Chair – 2013

2012 Rodin Garden Party Publicity Committee – Co-chair – 2012

2011 Rodin Garden Party Raffle and Swag Committee – Member – 2011

2010 Winter Gala Raffle and Swag Committee – Co-chair – 2010

2010 Rodin Garden Party Raffle and Swag Committee – Member – 2010

2009 Winter Gala Publicity Committee – Co-Chair – 2009

2009 Rodin Garden Party Publicity Committee – Member – 2009

Member – 2008 – present

The Raven Society of the Free Library of Philadelphia – Philadelphia, PA

Chair – 2011 – 2012

Board – Member – 2010 – 2015

Fall Event Committee – Co-chair – 2010 – 2011

Member – 2008 – present

Philadelphia Social Innovations Journal – Philadelphia, PA

Writer – 2010 – 2015

Young Friends – University of Pennsylvania Museum of Archaeology and Anthropology – Philadelphia, PA

Member – 2009 – 2012

Philadelphia Orchestra 21st Century Society – Philadelphia, PA

Member – 2008

Phi Beta Kappa – Delaware Valley Association – Philadelphia, PA

Member – 2009 - 2015

Phi Beta Kappa – Detroit Association – Detroit, MI

Member - 2003- 2008

Ohio State University – Columbus, OH

Medieval and Renaissance Performers Guild -

President - 1997-1999

Artistic Director -1998-1999

Secretary - 1997-1998

Member - 1995-1999

Honors Programming Board Cultural and Promotional Committees

Member -1995-1997

History Honors Programming Board

Facilitator - 1997-1999

Member - 1995-1999

Histhonors Listserv

Moderator - 1997-1999

Phi Alpha Theta

Executive Committee – OSU Chapter – 1997-1999

Member – 1996 – 1999